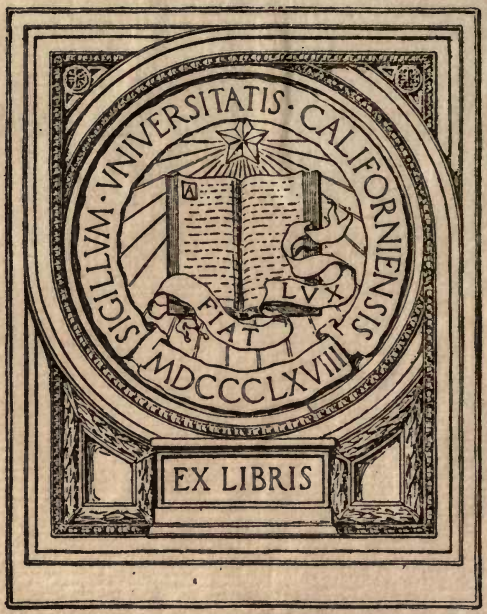
LABORATORY LESSONS IN GENERAL SCIENCE

BROWNELL


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LABORATORY LESSONS IN GENERAL SCIENCE



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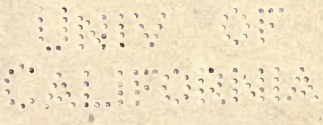
IN

GENERAL SCIENCE

BY

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PREFACE

THIS set of laboratory exercises in general science is an outgrowth of courses given by the author in methods of teaching secondary school sciences. Some of the lessons represent the combined efforts of a class upon an assigned topic, but so reshaped that credit to any individual is out of question. Free use has been made of material from the author's *Lessons in Astronomy*, *Chemistry*, *Nature Study*, and *Physics* — manuals prepared for his own class work. Many of the exercises have enough material for more than one lesson, and should be subdivided to suit teaching conditions.

The preparation of these lessons was stimulated by the belief that one chief cause of failure to get desired results with beginning classes in the high school sciences lay in the character of the material chosen. It was believed possible to bring together from scattered sources that which would appeal to beginners and which would find its unity in their life experiences and interests. This involved the rejection of much material of great worth from the differentiated high school sciences that is unsuited for an elementary course. Teachers subject to the exactions of schoolroom service do not have the time to make selections of material and properly to relate and adapt them for use.

The fund of life experiences available for a laboratory course about which science instruction of a general and

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elementary nature may center is large and should be more freely used by science teachers in secondary schools. These life experiences, supplemented by the experimental knowledge gained under direction in school, makes possible a fuller understanding of the teachings of books and a ready acquisition and grouping of a wide range of facts.

The emphasis placed in these lessons upon the interests of the individual, in both their personal and their community aspects, is expression of a conviction on the part of the author that topics of social science should not only be included in a general science course but should be treated in much the same way as are topics from the various fields of the natural sciences. Any unification of life interests and life problems with the spirit and procedure in science studies not only enriches the science teaching but reacts upon the daily living to make it more sane and more wisely ordered.

School work that requires discrimination in the importance of the facts involved in the affairs of life, that notes the bearing of these facts upon the well-being of the individual, and that formulates a rational course of action, not only develops a scientific attitude but it constitutes a training of inestimable worth in the education of youth. The varied interests of pupils are thus made centers about which to group newly acquired knowledge.

It is the author's belief that differentiation between the various sciences may be disregarded during the first year in high school. Emphasis is placed instead upon an interpretation of related scientific phenomena regardless of the fields into which any inquiry may lead. The relationship and unity indispensable in science studies is secured through a grouping of the interests and experiences of the

pupils rather than in the principles and laws of any branch of science. And it has been the aim to select as material for study not only that which is valuable in itself but that which at the same time is likely to be a stimulus in a truly educative process.

The author wishes to express his appreciation of the helpful suggestions and criticisms coming from those who have read the manuscript of these lessons. He desires especially to thank Professor George E. Martin, Head of the Department of English in the State Normal School at Kearney; and Dr. R. J. Pool, Professor of Botany in the State University at Lincoln. He is greatly indebted, too, for helpful suggestions from the following who have read portions of the manuscript: Miss Alice Loomis, Head of the Department of Home Economics at the State University of Nebraska; George E. Loveland, Professor of Meteorology in the State University and Director of the U. S. Weather Bureau; Dean E. L. Rouse, Superintendent of Practice in the State Normal School at Peru; Professor H. C. Filley, Head of the Department of Farm Management in the College of Agriculture; and Professor B. C. Hendricks of the Department of Physics in the State Normal School at Peru.

HERBERT BROWNELL.

LINCOLN, NEBRASKA.
1916.

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SUGGESTIONS TO TEACHERS

From his own observations and experiences the author ventures the following suggestions with the hope that they may be of assistance to teachers generally.

I. Laboratory Exercises

1. The laboratory requirements should demand no large degree of skill in manipulation of apparatus. In some of the lessons, better results will be attained if the teacher performs part or all of the experiments. Every exercise should be so shaped that it not only challenges attention to its results, but provokes inquiry concerning the meaning of what is noted. At all times large use should be made of the experiences of the pupils in order to secure a comprehension of experimental phenomena and an understanding of every new requirement of the lessons.

2. Very satisfactory results are attained where one period is given over to a discussion of the requirements of a laboratory exercise item by item *without previous study having been required of the pupils.* In this way there is in the class discussions a zest that comes from having something new, something that has not before been "studied." The common experiences of pupils and what has been learned in previous lessons afford ample preparation for such discussions. In this way it becomes possible not only to assemble and organize the knowledge possessed by

all the pupils, but to get before the individual pupils the results of the class thought as corrected and related under guidance of the teacher. A second period spent in the laboratory or elsewhere can then be given over to writing the results of these requirements, with such use of reference books as shall make this second period a study period even as was the first. These "laboratory papers," when returned to the pupils, should be preserved by them as their notebooks.

3. Assistance given pupils during these preparation (laboratory) hours may be of such nature that a consistent training in the neglected art of study is secured. To learn whence to get desired information, whether from books or from experimental data, and how best to proceed in acquiring it, ought to be one of the large factors in an education.

4. Some of the papers handed in at the close of every laboratory period must be carefully reviewed and corrected. All should be returned to the pupils before the next class period, some of them being marked "Not reviewed" when necessary. There is no more important means of securing information concerning the ability of individual pupils, and no better guide to teaching procedure, than is found in the review of some laboratory papers out of every set handed in. Often it is well to look over the papers of the same pupil every time for a while.

II. Class Work

All corrections and explanations of a general nature found necessary in a review of the laboratory papers should be made by the teacher during the class period.

Here is an unexcelled opportunity to impart much information that is closely related to what has been learned. Additional simple but instructive experiments by the teacher may be introduced here. The class-knowledge of each topic, whether gained from experience, learned in the laboratory, or gathered from books, is to be associated and unified by the teacher. If the laboratory hour be regarded as a time of preparation for instruction, the succeeding class period *is a time for teaching.*

When a textbook is used, or any large amount of reference reading is assigned, the teaching plan must provide for class periods given over more or less to quizzes upon the assignment, and to discussions and explanations to make sure that the readings are understood.

LABORATORY LESSONS IN GENERAL SCIENCE

I. LESSONS ON THE HUMAN BODY

To THE PUPIL. — In the lessons that follow much useful information may be learned about many things with which we are already more or less acquainted. Wherever it is possible we shall study these things directly, and try to answer important questions about them. To the information gained in this way we shall in many cases add the knowledge gained from books. From these observations, from experiments, and from books, we are to get all the information we can. Every question asked and every requirement made is of the nature of a problem for us to solve. We are expected to find a reasonable answer for it. Sometimes we shall want to know not only that a certain thing is true, but why it is true, and what difference it would make to us if it were not true. That means that we must not only learn the facts, but we must consider what they mean. The questions asked will guide us in doing this. Doubtless many other questions will occur to you whose answers you will want to know. Consult freely all books at hand likely to give the information you want.

THE HAND

1.[1] Which part of the arm as a whole is the hand? What name is given the part where the hand joins the forearm?

2. After moving the fingers in all possible directions, state what is true (*a*) of the freedom and variety in their movements; (*b*) of the number of muscles required for these movements.

[1] In these laboratory exercises the paragraph numbering is to be observed in the written work handed in. This will aid in the correction of the papers.

3. While the left wrist is held in a close grasp by the right hand, observe any movements through the wrist as the fingers of the left hand are moved about. Explain what is seen and felt.

Take firm hold of the forearm just below the elbow; move the fingers freely, and explain any movements noted in the arm. What purposes are served by having these muscles so far away from the parts moved by them?



FIG. 1.— Muscles and tendons of the hand and forearm.

4. By what other means than the use of many muscles is variety in movements of the hand secured? Count the bones (*a*) in each finger, and in the thumb; (*b*) across the thick part of the hand. What purposes are served (*a*) by binding together the bones forming the palm of the hand; (*b*) by having the thumb so loosely connected? What advantage results from having one less bone in the thumb than in a finger?

5. What name is given to the inner side of the thick part of the hand? What is the name given to the union of any two bones? What special name is given the places where the fingers are joined to the hand? What kind of motion only is possible in the joints of a finger? What purpose is served by these limitations in the freedom of finger movements?

6. State very definitely the location of the nail on a finger. Describe the general shape of the finger nails, and any markings on them. What is peculiar in the growth of the nails? What are their uses? What care should be given them?

7. Describe the appearance of the skin in the palm of the hand. What variations are noted in its thickness? Account for the deep markings in the palm of the hand.

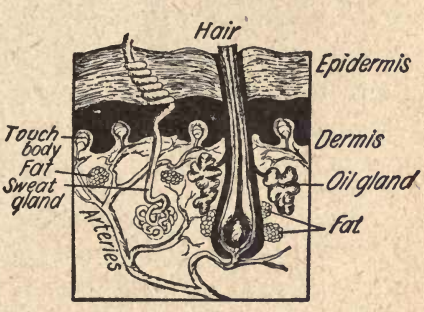


FIG. 2. — Cross section of the skin greatly magnified.

8. Name several important uses of the hand. State what difficulties would be experienced by a person who had lost both hands. Because of lack of hands how must animals feed themselves? What is true in a general way of the adaptation of the hand for ministering to the needs of man? Name several uses of the hand that illustrate the skill to which it may attain. By what means are hands and fingers made to act in obedience to the mind?

THE MOUTH

1. In what part of the head is the mouth cavity? Name the walls by which it is surrounded. To what else besides the cavity is the term mouth applied?

2. Describe the structure of the lips. What is the form and size of opening between the lips when wide apart? How

much freedom of motion have the lips, and how is this secured? Name the several uses of the lips.

What can be told of a person's feelings by noting the lips? How may lip expression be affected by an oft-repeated emotion? Explain the redness of the inner surfaces of the lips and of their edges.

3. Of what use are the cheeks? What is their structure?

4. Observe the rear wall of your mouth as seen in a small mirror, and describe what you see. Name its various parts. What is the name of the cavity farther back?

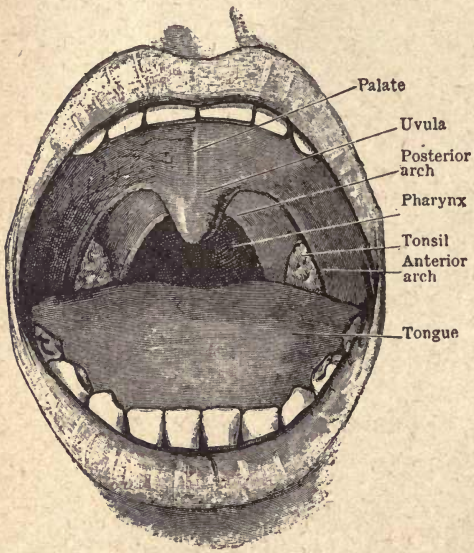


FIG. 3. — The mouth cavity.

5. What is the character of the roof of the mouth? Which wall of the nasal cavity is it? If all the walls of the mouth were of bone, in what respects would its usefulness be affected?

6. Describe the structure, lining, and general appearance of the floor of the mouth after studying it closely with the aid of a mirror. Note the movements and the structure of the tongue, and explain its mobility. With the finger-tips pressed against the outside

of the throat about where the tongue seems to be rooted, ascertain if possible to what it is attached. Of what advantage is an attachment of this kind?

7. Describe the form, size, color, and coverings of the tongue. Note how it may be rubbed against the roof of the mouth, and state what is accomplished by this action in eating. Mention other uses of the tongue in eating.

8. For a person who is in good health what is the appearance of the tongue as to (*a*) moist look; (*b*) coatings? What information is really sought by the physician when he "looks at the tongue"? What is *tonsillitis* (tŏn-sĭ-lī′tĭs)?

9. State the location of the teeth in the mouth cavity, and their general arrangement. Why would it not be as well to have muscle in place of bone for the jaws?

10. State the number, general characteristics, and duration (*a*) of the first set of teeth; (*b*) of the permanent set. Classify the permanent teeth according to form. State the number, form and special use of each of these groups.

11. Name the parts of a tooth. Which part is exposed in the mouth? What are the gums? Why should we take good care of the teeth? How often should at-

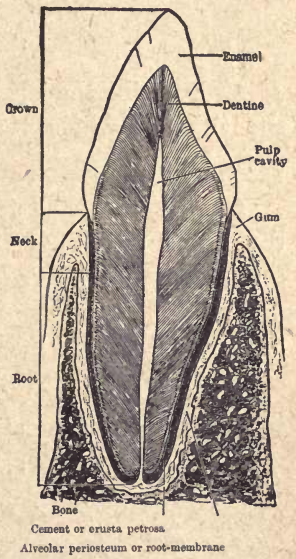


FIG. 4. — Cross-section of a tooth.

tention be given them? What should be done, and what avoided, in order to preserve the teeth?

Make a study of a tooth obtained from a dentist, or elsewhere, and tell the place and nature of (*a*) *dentine;* (*b*) *enamel;* (*c*) *pulp.*

12. Where are the voice sounds produced? What is the function of the mouth in speech? What are the bad results of breathing through the mouth? What are *adenoids,* and when may their removal become necessary?

13. Aside from its use in speech, what is the chief use of the mouth? What uses has the *saliva?* By what is its flow affected? Where is it *secreted?*

THE EYE[1]

1. Describe the location of your eyes with regard (*a*) to the body as a whole; (*b*) to the face as a whole; (*c*) to the nose.

2. Of the eyeball tell (*a*) its estimated diameter; (*b*) the general form of it as seen with the eyes widely opened; (*c*) the names of the several visible parts; (*d*) the form, color and relative position of each part. In which part of the eyeball can changes in size be noted?

3. Watch closely the movements of the eyeball, and tell in what directions it can be made to move.

4. Make observations of the eyes of several people and state what differences you observe (*a*) in the depth to which the eyes are set in the head; (*b*) in the amount of ball exposed;

[1] Use a small mirror for the study of your own eye.

(*c*) in the general appearance, luster, expression, movement and other characteristics.

5. Mention any important purpose apparently served by having the eyes placed (*a*) so high up in the body; (*b*) at the surface rather than deeply set.

6. What protection has the eyeball (*a*) at the sides; (*b*) in front?

7. Of the eyelids state (*a*) the significance of the name; (*b*) their structure; (*c*) the form of each when the eye is closed and when open; (*d*) their relative size; (*e*) the amount of motion for each; (*f*) the place of the eyelashes.

8. Describe the nature, form and length of the eyelashes. What is their apparent purpose?

9. State (*a*) what would result if the secretion of the tears were to cease; (*b*) how the tear-water is spread over the eyeball; (*c*) how much of the time the eyeball is kept moist; (*d*) from what point under the lids the tears flow; (*e*) the significance of water running from the nose when one cries; (*f*) why the tears do not overflow the cheeks all the time; (*g*) the course of the tears across the ball.

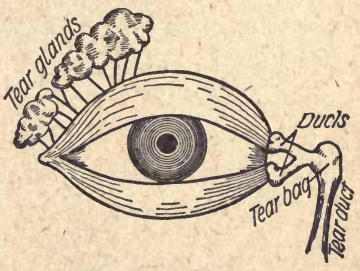


FIG. 5. — The tears.

10. When a bit of dirt or any solid particle gets under the eyelid, what may be done to remove it?

11. What uses have the eyebrows? In what respects are they unlike in different people?

12. What defects of the eye are common?

13. What care should be taken of the eyes as to (*a*) direction whence light comes; (*b*) amount of light; (*c*) continuous use of the eyes; (*d*) general health?

14. Discuss briefly the importance of sight.

II. HEAT IN RELATION TO THE HUMAN BODY

COMBUSTION

1. Put a long, narrow lamp chimney down over a short lighted candle set in a dish containing a little water. Repeat several times, and state what occurs. Account for the result.

Repeat these tests, having a partition of tin reaching down through the chimney at one side of the burning candle. Hold an extinguished match that is still smoking at the top of the chimney, first on one side of the tin and then on the other, and observe the smoke. What is the significance of the behavior of the smoke?

2. Let the teacher carefully melt a little potassium chlorate in a test tube, and then heat it to boiling. Observe the results as bits of match sticks are dropped into the hot liquid.[1]

The gas, *oxygen*, is set free from the chlorate as result of a chemical change, and the union of the oxygen with the wood is another chemical change.

What is true (*a*) of the nature of *combustion;* (*b*) of the composition of air in order that it may support combustion of the candle?

[1] It will be a wise precaution to fold a strip of paper into several thicknesses, and wrap it about the upper end of the test tube as a holder. If the tube be heated nearly its full length at first, there will be less likelihood of breaking it when water from the crystals of the chlorate is driven off.

The rusting of iron and the decay of vegetation are illustrations of oxidation. Why are these not commonly considered cases of combustion?

3. Into an evaporating dish put a teaspoonful of gasoline. Bring to it a lighted splinter, and observe.

Half fill another dish with kerosene, and test in like manner. Pour out all but a little of the kerosene and warm slowly what is left, testing frequently with a lighted splinter held just above the dish. What is the nature of *flame?*

4. Light a candle. After a moment extinguish it, and immediately hold a lighted match just above the wick. Repeat several times, noting whether the wick can be ignited when the flame is some distance from it. How is this possible? What is the "flame" of a candle? What conditions are necessary for any flame? Name in order the steps in the ignition and continued combustion of a candle.

5. Note the parts of a candle flame distinguished by color, and state their relation to the wick and to one another. Hold in the candle flame just above the wick the wood part of a match, withdrawing it after a moment to observe the positions of the charred parts with reference to the parts of the flame. Repeat several times, and infer concerning the interior of the flame.



FIG. 6. — Parts of a candle flame.

Press down over the candle flame nearly to the wick a sheet of white paper. Withdraw it before the paper ignites, and observe the form of the charred portion. From several such attempts reach a conclusion as to the interior of the flame.

Describe the parts of a candle flame as to nature and form.

Explain the persistence (*a*) of the inner cone; (*b*) of the wick.

6. Put the tip of a blowpipe into the inner cone of the candle flame, and by repeated trials cause the yellow part of the flame to very nearly disappear. What is the explanation of this change?

Hold the inner edge of an evaporating dish in this blowpipe flame for a moment. Then hold another part of its surface in the candle flame. Observe any deposit on the dish in either case, and state its probable nature and source. Account for any variation in amount of the deposit in the two cases. Give an explanation of the light-giving power of the yellow part of the candle flame.

7. Hold a clean dry bottle mouth down over a burning candle, and look for any moisture (water) on the sides of the bottle. Assuming that there is no water in the candle material, account for its appearance in the bottle.

Observe a lighted splinter when it is put down into the bottle that has just been held over the candle flame, and explain the results. Set the bottle aside with a cover on it. When it is cold put into it a little limewater (10 c.c.) and shake. Any milky appearance of the limewater is due to the presence in the bottle of the gas *carbon dioxide.*

8. Breathe through a glass tube into limewater in a test tube till a marked change occurs in the appearance of the limewater. What is the significance of this change? What is indicated concerning processes within the body? Whence is derived (*a*) the oxygen; (*b*) the carbon? In what respects does this oxidation within the body differ from ordinary combustion? What significance has the fact that

people in cold weather and in cold climates crave fatty foods? What is the normal temperature of the body?

9. What are signs of lack of oxygen in the air that we breathe? By what means other than respiration may the air of our rooms be robbed of its oxygen? What provision does nature make to rid the air of carbon dioxide and restore oxygen to it?

VENTILATION

1. Over two holes cut in the cover of an empty cigar box set chimneys made air-tight at the bottom with vaseline. Have a bit of candle burning within one of the chimneys. Test for *air currents* at the tops of the chimneys by means of smoke from an extinguished match (or joss stick). Explain in full what is discovered.

What is true of the relative temperatures of the air in the two chimneys? In what other respects is the air above the candle unlike that in the other chimney? How was the air in the box affected because of the differences in temperature of the air in the two chimneys?

2. Why does the air of a schoolroom need to be continuously changed? At what season of the year is it necessary to give especial attention to this matter? What economic considerations are to be taken into account in the ventilation of rooms in winter? What danger to health must be avoided? What change should the outside air in winter undergo before it is allowed to spread through an occupied room? By what means other than that employed above might a current of air be maintained through the rooms of a building?

3. To secure desired changes of air in rooms of a building provided with air-shafts, but without fans or other devices for forcing air into and out of rooms, what must be true at all times (*a*) of the relative temperatures of air at inlet and outlet; (*b*) of the place for outlet that no warmed air escape without yielding for use its oxygen; (*c*) of the place of inlet that the cold air be warmed before it spreads through the room? What devices may be employed to break up an incoming cold air current and divert it upward?

4. Hold a lighted candle (*a*) at the top of an open doorway; (*b*) down at the floor. Repeat the tests at narrow openings made by lowering the upper sash of a window, and raising the lower one. What objections are there to ventilating rooms in either of these ways in cold weather?



FIG. 7. — A victim of oxygen starvation becomes an easy prey for tuberculosis or other germ diseases.

5. Why is there need of special attention to the ventilation of our sleeping rooms? How may this be provided even in the coldest weather? What are some of the results of inattention to ventilation of sleeping rooms? What is the change in composition of the air of a room where gas lights or oil stoves are kept burning?

6. That the lungs may be able to perform their work (*function*) well, and make use of the available oxygen, in what condition must the tissues of all their parts be? What in general are the two requisites for the healthy condition of any organ of the body? Why is a diseased state of the lungs less likely in a person who leads an active out-of-door life? What is *tuberculosis* of the lungs?

RESPIRATION

1. With the hands held firmly against the chest walls at the sides, take several deep breaths. Describe in a general way what motions of the walls are noted. What name is given that part of the breathing process in which air (*a*) goes into the lungs; (*b*) is expelled from the lungs?

2. Name in order the principal passage-ways through which air goes on its way to the lungs.

3. Compare the movements of air passing into and out of the chest during *respiration*, and into and out of an accordion while being played.

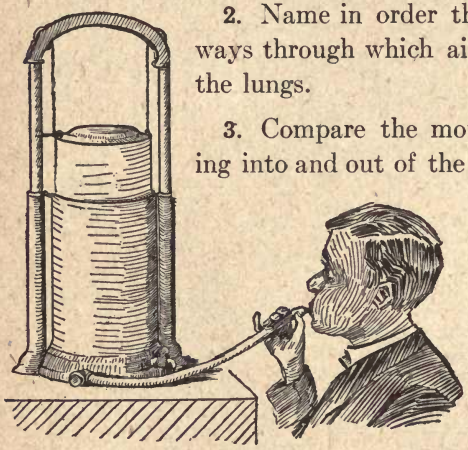


Fig. 8. — Using a spirometer to test lung capacity.

4. Sitting erect and in a comfortable position, count the number of exhalations per minute in your breathing.

5. Fill a gallon jug with water, and close with a stopper. Let the teacher invert the jug, and with its mouth under

water in a tub or sink remove the stopper. Holding the inverted jug tipped sufficiently, let one end of a rubber tube be put up through the neck of the jug. Have some one of the class fill his lungs to their utmost capacity, and then through the tube force out into the jug as far as possible all air from the lungs, withdrawing the end of the tube from the jug before taking the other end from the mouth.

Keep the mouth of the jug under water and replace the stopper to retain in the jug all the water not displaced by the exhaled air. Remove the jug from the water, set it right side up, and by use of a graduate ascertain the volume of air expelled from the lungs by measuring the quantity of water needed to refill the jug.[1] [Lung capacity is tested most satisfactorily by use of a spirometer.]

6. In like manner, and as average of several trials by the same person, determine the volume of a natural (not forced) exhalation.

7. From the results above, calculate what per cent of the air capacity of the lungs was used in once breathing. Infer a good purpose served (*a*) by an occasional long, deep breath; (*b*) by not having the lungs emptied of all air at every breath.

8. From the data above calculate the volume of air taken into the lungs (*a*) per minute; (*b*) per hour. About one fifth of this is oxygen.

Calculate how long it would take the individuals present in the room to breathe as much air as the room contains, using the same air but once.

[1] 1000 c.c. (1 liter) is equivalent to about 64 cubic inches.

9. Close the lips tight, take a deep breath, hold the nostrils tight shut with thumb and finger, and note the length of time you can refrain from *exhaling*.

10. Expel the air from the lungs as fully as possible, and note how long you can keep from *inhaling*. Account for its being a shorter period than for exhaling.

What would be the result of shutting off from the lungs all air supply for even so short a time as 10 or 15 minutes? What is the real nature of death by drowning?

11. State so far as known to you the steps taken to resuscitate (restore to life) a drowned person, together with the purpose of each step. What is meant by *asphyxiation* (ăs-fĭk-sĭ-ā′shŭn)?

THE HUMAN BODY AS AN ENGINE

1. From a general knowledge of steam engines, state (*a*) the purpose of burning fuel in the fire box; (*b*) the need of a draft.

2. What is true of the relative amount of fuel needed when the engine is (*a*) working full capacity, and when more or less inactive; (*b*) well protected from the cold, and when left exposed? By what means is water changed into steam? What then is there in the steam that does the work for which the engine is employed?

3. What will be the effect (*a*) if the fuel supply is exhausted; (*b*) if the draft is shut off for any considerable time?

What is true of the power of the steam engine when there is insufficient heat? What is the significance of escaping steam when a locomotive is not at work?

4. Why may death result if the temperature of a person's body continues for some time several degrees below normal? What is evidence of a superabundance of *energy* in a person?

5. What in our bodies corresponds to fuel for the engine? Name several kinds of body fuels. Before these become available as fuel what changes must they undergo in the body?

6. What part in this heat production has respiration? Where does the oxidizing action go on, and where in the body is heat liberated? What part in all this has the circulation of the blood?

7. Recall the effects of vigorous exercise, whether of work or play, upon (*a*) the rapidity and volume of breathing; (*b*) the rate of pulse beat; (*c*) the temperature of body. Explain the relationship of these conditions.

8. How much of our thought and attention do the processes of digestion, respiration, and circulation of blood commonly require? In case we did need to give these activities our attention, how would it affect us in the affairs of life?

REGULATION OF BODY TEMPERATURE

1. Dip the hand into water; then wave it back and forth in the air and note the sensation. Hasten the evaporation by fanning, and observe any difference in the sensation. Whence is derived part at least of the heat necessary to vaporize the liquid? What is true of the temperature of the body when *perspiration* vaporizes on the skin?

2. What is the nature of perspiration? What is meant by a *secretion?*

3. What relation is commonly noted between the temperature of the body and the amount of perspiration?

4. State clearly and somewhat in detail the natural provision that has been made to avoid excessive temperatures in the body. What is the apparent relationship between excess of heat in the body, amount of perspiration, and the disposal of this heat by vaporization?

5. What care should be given the skin that it may be in condition to regulate body temperature? How do we protect the body from sudden extreme temperature changes? Why is there danger in wearing wet clothing?

6. In what ways has man provided against excessive loss of body heat by radiation to the surrounding air? Why is there risk to health by exposure of neck and chest in cold weather? Why should a person wear rubbers in wet weather?

7. What is likely to be true of the temperature in any organ or part of the body (*a*) where the blood vessels are continuously gorged with blood; (*b*) where for any cause excessive oxidation is taking place? How is the weight of the body affected by a combination of excessive oxidation and impaired digestion?

III. HEALTH AND WELL-BEING

KEEPING WELL

1. When one is seriously sick, what are some of the usual expenses of the sickness?

2. In a general way what constitutes the difference between being sick and being well — between having good health and being diseased?

3. What may commonly be expected sooner or later as a result of an unhealthy or diseased condition of the body?

4. What good purpose is served by pain? What commonly follows neglect to heed the first warnings of pain?

5. When a physician is called in case of any illness, what will he seek to discover before prescribing any treatment? Why?

6. What constitutes the best course for anyone to follow, whether under direction of a physician or not, as regards air, food, drink, sleep, exercise? In what respects other than drink does one need to be "temperate"?

7. What is commonly true of the body temperature as a result of serious illness, or of conditions in the body likely to cause sickness? Why is it well to have for family use a thermometer such as physicians carry?

8. In what sense may it be said that some people cultivate sickness rather than health?



FIG. 9. — This position makes impossible the full deep breathing necessary for health.

9. What effect on the return of blood to the heart has muscular exercise, whether work or play? What in the appearance of a person is evidence of a sluggish circulation?

10. Why is work a blessing rather than a curse to man? When does it become a curse?

INFECTION

1. It is known that the cause of many of the diseases that are "catching" is the introduction into the human body of living organisms so minute as to be seen only when examined under the microscope. These are very properly called microörganisms, or *microbes*, or simply *germs*. Many of these are minute forms of plant life known by the name of *bacteria*. Once lodged within the body these germs, under conditions favorable to their growth, will multiply in number at a truly marvelous rate, and directly or indirectly bring about a diseased condition in the patient. What is the meaning of the term *bacteriology?*



FIG. 10. — Size of bacteria relative to that of the point of a fine needle, both greatly magnified.

The microscope is to the bacteriologist very much what the telescope and its accessories are to the astronomer. Ascertain the literal meaning of the terms (*a*) microscope; (*b*) telescope.

2. Fortunately the number of kinds of germs which cause disease in persons is relatively small. The symptoms of the ailment and the degree of danger to the life of the patient vary with the kind of germ, its vigor, and the state of health of the person. In some cases the development of the germs after their introduction into the body can be checked or prevented; in other cases the disease must run a course dependent upon the life changes through which the germ passes. In such cases whether the patient lives or not depends in large measure upon his powers of endurance. Explain the weakness of body incident to long-continued sickness. Aside from feeling a need for it, why is it better when sick to keep quiet, even remaining in bed?

3. When persons recover from a germ disease the system often seems to remain for a considerable period of time in a condition unfavorable to any new development of the kind of germs that caused that disease. Ill effects may not be experienced from them for a long time. One is then said to be *immune* to that particular disease.

A like condition is often brought about under direction of a physician by processes of *inoculation*, or *vaccination*. There is introduced into the system a specially prepared *virus*, or *serum*. This causes a mild form of the ailment, and leaves the patient for a time immune to any severe attack, and possibly to any attack at all of that disease.

The life products of the disease germs within the human

body often act on the tissues as poisons, or *toxins*. They are destructive of the life of the tissues. Remedies that counteract the effects of these products, or that prevent their formation by preventing multiplication of the germs, are called *anti-toxins*.

To secure immunity against what diseases are persons vaccinated? For what ones are serums administered?

4. When the skin on the body is cut or torn, germs may find lodgment in the wound. Their development and multiplication may cause an unnatural secretion called *pus*. This pus, and the toxins it contains, when absorbed into the blood and circulated throughout the system may cause *blood poisoning*. Aside from the desire to relieve pain caused by pressure, why is a physician or surgeon often employed to lance any serious swelling, *e.g.*, a boil? Various substances, applied promptly to wounds and to bandages used, either destroy the germs or make conditions unfavorable to their growth and development. Such substances are called *antiseptics*. (*Septic* has reference to putrefaction of animal tissue.) Modern surgery owes much of its success to the use of antiseptics. Where the tissues of a wound are kept free from germs and in a healthy state, rapid healing is possible.



FIG. 11. — Sterilization by boiling.

The absolute destruction of the life of these germs, whether by action of chemicals or by high temperatures, is called *sterilization*. The surgeon is exceedingly particular in all

operations that his instruments, his person, and his clothing are sterilized.

"First aid" treatment for the wounded, whether on the battlefield or elsewhere, seeks by the use of antiseptic treatments at once, and before removal to any hospital, to prevent the infection of the wound, *i.e.*, the introduction into it of germs. What is the explanation of pus formation in a wound? What in general may be considered one of the chief functions of the skin?

5. In what ways other than through breaks in this protective covering of the body may germs be introduced within the body? In what several ways may the presence of the long-lived typhoid germs be accounted for (*a*) in the water from wells and from city water systems; (*b*) in milk for family use and for sale; (*c*) in fruits purchased in market and vegetables gathered in a home garden? What part are flies believed to play in the spread of typhoid?

6. Where germs causing disease are communicated by contact with infected persons or their clothing, the disease is spoken of as *contagious*. Many communicable diseases may be classed as both contagious and *infectious*. What precautions are usually enforced to prevent the spread of smallpox and diphtheria (dif-thē′rĭ-à) as contagious diseases? In cities and towns, who has the responsibility and the power to enforce regulations to this end? Why are the periods of *quarantine* for different contagious diseases of different lengths? What does the physician do to avoid carrying contagious disease?

7. In order to avoid infection various means are employed to destroy the germs likely to be present in the clothing, and

in the waste matter of the sick room. What exact meaning have the words disinfect and disinfection? What is a *disinfectant?* What is the safest course to pursue with regard to clothes used by a sick person, and all bedding and furnishings of small value? In case infected clothing is not destroyed, how is it to be cared for until it is washed? What disinfectant may be put into the wash water? Why should the cover of the wash boiler be kept on while the clothes are being boiled?

8. In case a room is to be disinfected, what kind of disinfectants may be used to insure the destruction of germs lodged upon walls and furniture, and within blankets, heavy clothing, and carpets?

State just how to proceed in this disinfecting process. How much disinfectant should be used, and for how long a time?

9. How should dishes from the sick room be treated? How should all waste matter from the sick room be treated before disposing of it in sewer or cesspool?

10. What measures may be taken for the protection of the public health where through ignorance or carelessness a family fails to observe proper precautions? What can be done when there is willful neglect by a family to carry out the directions of the physician and nurse?

SANITATION

1. When people are sick every effort should, of course, be made for their complete recovery. But it is better for them as individuals, and better for any community, to strive to prevent sickness and disease. Aside from the suffering and

hardship involved, sickness is wasteful. No one can afford it. About what is the expense in bills for doctor, medi-

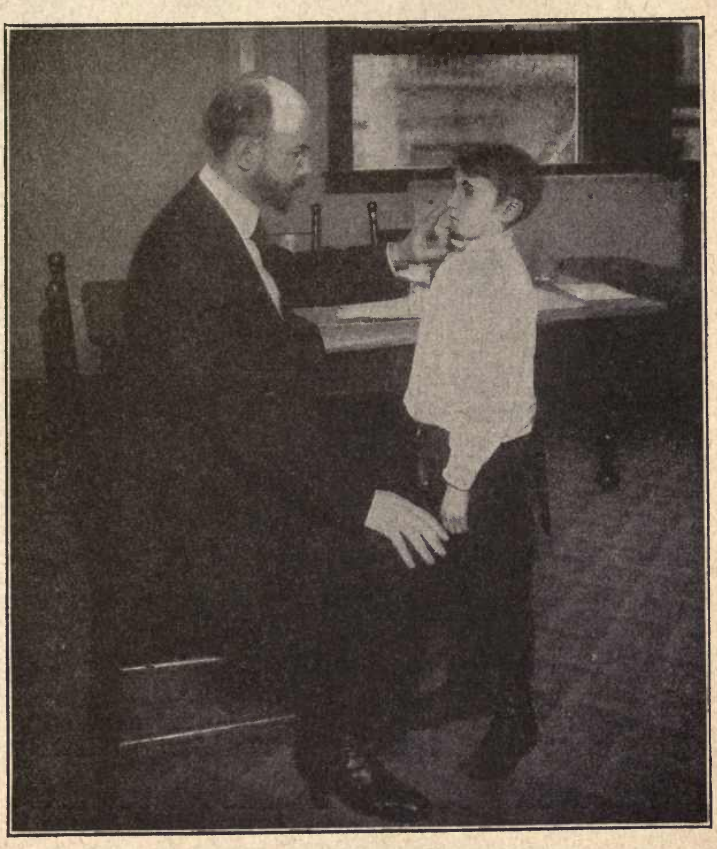


FIG. 12. — The school doctor.

cines, and nurse during a month's serious illness? Name several other ways in which there is loss through sickness.

Ascertain the significance of the terms *sanitary, sanitation, insanitary.*

Cleanliness and wholesomeness should characterize every part in the process of food preparation. Because it is impossible for consumers to know the conditions under which the foodstuffs sold in market have been prepared, and whether these foodstuffs are of the quality and weight represented to purchasers, there has arisen need of Pure Food Laws and of provisions for their enforcement. Why is the need for sanitary precautions in handling food supplies imperative? What conditions must be observed in the care of food in our homes?

2. Explain why sleeping in small closed rooms in winter, or working in overcrowded rooms not properly ventilated, is insanitary, aside from the danger of oxygen starvation.

3. Why is it that open sewers and rotting piles of garbage and stable refuse are insanitary? What is the common means of protection of our homes from the flies that breed in such places? What is a better course? Why is there a menace to health in the exposure of foodstuffs to dust blown about on city streets? What precautions should be taken against infection with malarial germs? Why are not all mosquito bites equally dangerous?

4. How may ice become a carrier of infection? What care should be exercised (*a*) where food is kept in refrigerators; (*b*) in the use of ice for cold drinks? Why is it that food does not spoil so soon when kept cold in a refrigerator?

5. Why is there greater need of attention to sanitary measures now than formerly? What is the penalty of carelessness and ignorance in these matters? Are cases of sickness made more dangerous because of a better knowledge of the nature of infection? What on the other hand is

gained by reason of such knowledge? What results are sought in a widespread enlightenment of people in matters of health? How many people have need of such knowledge? Why is it an even greater need than a knowledge of how to cure illness?

THE WATER SUPPLY AND HEALTH

1. Account for the supply of water (*a*) in shallow wells; (*b*) in very deep ones. How is the caving in of dug wells commonly prevented? How is surface water to be kept from running into such wells? Why should there be a tight-fitting cover over the well?

2. Describe the general character of the upper layers of the earth's crust that makes possible an ample water supply

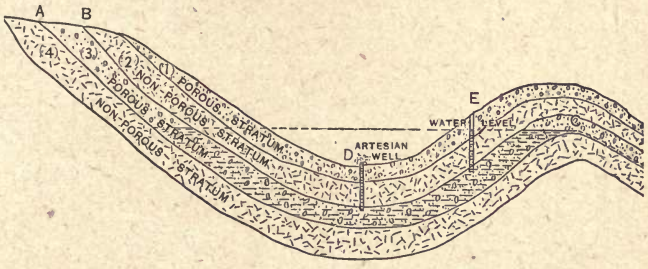


FIG. 13. — Conditions for wells.

when pipes are driven through them. Illustrate by diagram the conditions that make *artesian wells* possible. How is the heat of certain springs and of geysers accounted for?

3. Discuss the necessity for care in locating wells near dwellings and outbuildings. What element of danger is there from cesspools, drains, and leaky sewers even when

the well is on higher ground? What special dangers are there in the use of well water in towns?

4. Describe somewhat in detail the construction of cisterns. What difficulties are experienced in providing for a water supply by storage in cisterns? What advantages are there in the use of cistern water rather than well water? State objections to its use for drinking and cooking. Aside from the possibility of disease germs in it, why may drinking cistern water cause sickness?

5. By use of a diagram show the construction of a cistern having a filtering wall of porous brick, and indicate suitable places of inlet and outlet for the water. What precautions should be taken to keep cistern waters free from dust and from organic matter? What difficulties are there in filtering rainwater as it goes into the cistern? What conditions in a city usually make the use of cisterns impossible?

6. Describe the action of the "chain pump" as a means for aerating cistern waters. Explain the nature of the chemical change thus accomplished in the water. Account for the odor and taste of cistern water.

7. Tell something about an air-pressure system for supplying water to all parts of a house from a cistern.

8. State the source of the water supply of your city. Describe the manner of its storage and distribution. What is the cost of water to a consumer? What protection has this water supply from contamination? What means are employed, if any, for its purification?

9. What danger is there in the use of water from streams? What advantages may there be? What is generally true of

the purity of spring waters? By use of a diagram show how springs arise.

10. Where the water supply of a city is drawn from a river into large storage reservoirs, (*a*) what provision is made for filtering on a large scale; (*b*) what means other than filtering is employed to rid the water of suspended matter; (*c*) what method is employed on a large scale for the aëration of stored waters?

11. Where there is reason to suspect the purity of a water supply, what wise precaution should be followed in the home to avoid danger of infection from the water? How may it be determined whether or not there are "germs" in the water supply? How is it learned what particular disease germs are present?

GENERAL HEALTH PROBLEMS

1. Name several conditions wholly under the control of an individual that contribute to the public health. Mention others, present especially in towns, that are not wholly controlled by him.

2. Describe in a general way how infection occurs. Distinguish between infection and contagion. What relation has one's general state of health to "taking" a disease? What is the physiological explanation of this?

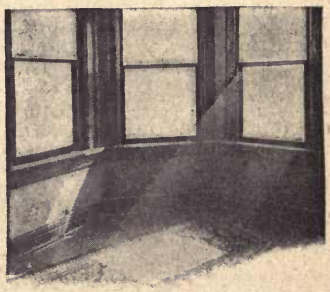


FIG. 14. — Sunshine as a disinfectant.

3. Write briefly the main features of the life history of *mosquitoes*. What is one way to destroy them in great numbers, and to keep rid of them in an infested region? What more may be necessary? What part is played by one kind of mosquito in the spread of yellow fever? What must be done in order to prevent the spread of this disease?

4. Relate somewhat at length the life history of the common *house fly*. At what rate do flies multiply under favorable conditions? What conditions are favorable? What is the procedure in a warfare for their extermination?



FIG. 15. — The house fly (magnified). Note the hairs on legs and body.

5. What is the manner of disposal of *garbage* in your city? In what respects is there menace to health in such a course? What better ways are employed by other cities?

6. In the installation of a *sewage* system for a town, what must be provided for moving the waste material through the sewers?

7. What is an estimated amount of property losses through the depredations of *rats* every year? How are buildings made rat proof? Rats are charged with being agents in the spread of the dreaded Asiatic plague. How is this believed to occur? What is done to exterminate them in a city where the plague has obtained a foothold?

8. Why do we have *health ordinances*, and health officials? What are the duties of a Board of Health? Why is there

need of a well-informed citizenship in matters of public health? What can the individual citizen do to aid in maintaining public health?

9. Mention one or more instances known to you of the enforcement of *pure food laws.* What are the duties of State Food Inspectors generally? How may violations of the pure food laws be stopped? What are desirable health regulations in the sale (*a*) of milk; (*b*) of fruits and vegetables?

10. Explain the preservation of foodstuffs (*a*) by employment of low temperatures, as in *cold storage;* (*b*) by use of high temperatures, as in sterilization of milk and in *canning* foodstuffs; (*c*) by use of salt, vinegar, sugar, etc., in the pickling processes; (*d*) by use of smoke in the curing of meats. Why then is it considered so harmful to put formaldehyde in milk, boric acid in meats, and salicylic (săl-ĭ-sĭl′ĭk) acid in fruit products in order to preserve them?

11. What are the advantages in cold storage of perishable foodstuffs? Why is there need for public control of these storehouses?

12. What revolution has been wrought in the problem of food supply by the rise of the canning industry? Why is the control of this industry in the interests of public health a comparatively easy problem?

LIFE, GROWTH, REST AND RECREATION

1. How can we tell whether a tree is dead or alive? In what ways can it be decided whether an animal is dead or not? In general, how may plants be distinguished from animals? The *protoplasm* (prō′tō-plazm) of the cells in

plants and animals is the material that is alive. Just what this "life" may be, making the difference between living and dead tissues, remains unknown to scientists.

2. Growth of the tissues is commonly accomplished by the subdivision of living *cells*, apparently from causes (activities) wholly within the cell itself. These new cells are like the original cell, and are in turn capable of subdivision. In the case of the microscopic plants known as



FIG. 16. — Successive stages in the subdivision of a cell.

bacteria, subdivision under favorable conditions is said to occur as frequently as every twenty or thirty minutes. Calculate in round numbers how many of these one-celled bacteria could result in twenty-four hours from a single cell where subdivision of every cell occurred every half hour.

3. In the higher orders of plants, and in animals, the formation of a more complex cell structure is far slower than this, and in active animals like man a fairly even balance is maintained throughout much of one's life between increase in new cells and the destruction of others. Why may any considerable loss in weight during middle life, or failure during youth to increase somewhat regularly in weight, be a cause for concern?

4. Activity in some form is an accompaniment as well as an evidence of life. A low degree of physical or mental activity is oftentimes evidence of a lack of sound conditions

of body. State the relation of physical vigor (*a*) to an insufficient supply of nourishing food; (*b*) to poor digestion; (*c*) to imperfect assimilation; (*d*) to lack of pure air, sufficient sleep, and suitable exercise.

5. In what one organ of the body are largely centered the activities upon which the mental processes depend? In

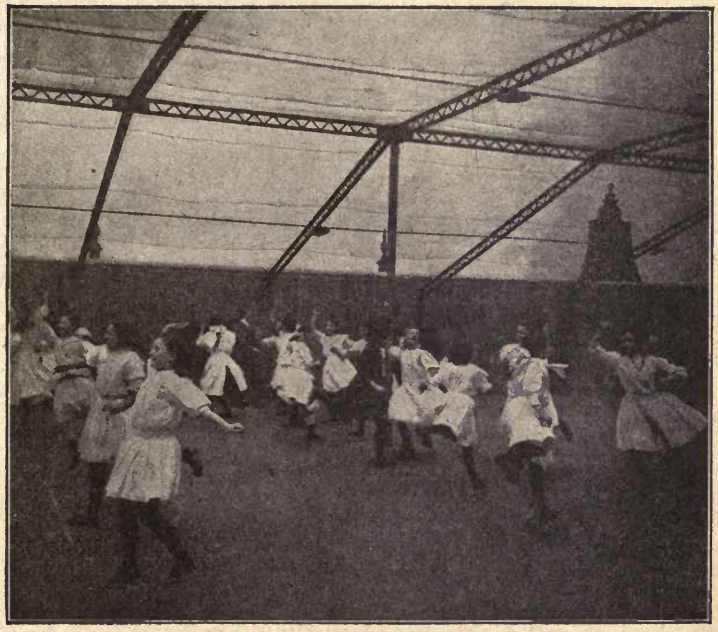


FIG. 17. — Recreation at school.

general how much does its development depend upon muscular prowess? Muscular exercises and physical training should be directed chiefly to what ends? What is the argument for school athletics (*a*) where all pupils have opportunity to engage in them; (*b*) where but a few are trained whose

contests are to be witnessed but not participated in by the school body at large? What evils in matters of health result from over-training and excessive efforts? Why is it that change in occupation may afford refreshment? How is it that activities employing both hand and head are often less tiresome than either mental or manual labor alone?

STIMULANTS AND NARCOTICS

1. Stimulating trade, stimulating political interest, stimulating public opinion, are expressions frequently heard. What is there common in their meaning?

2. In what ways may a shower bath, or a sponge bath, have a stimulating effect upon the body? What effect of hot drinks taken into the stomach warrants speaking of them as *stimulants?* Why is the alcohol of various drinks and medical preparations a stimulant for the human body?

3. When a horse is stimulated under vigorous use of the whip to make unnatural efforts in moving heavy loads, what harm to the animal is likely from these efforts? What harm to the organs of the human body will probably result from the use of alcoholic drinks even in small quantities?

4. What is true of the number of people who begin the use of alcoholic liquors and become addicted to the drink *habit,* after they are thirty years old? What significance has this? Why is it that young men beginning the use of intoxicating drinks are likely to become drunkards though not planning to do so?

5. Name some advantages to a person in having formed the habit of doing what is for his own welfare. What is the explanation of habit as a condition of the body? In

what sense is alcoholism a disease? Why do so few recover from it?

6. Apart from the use of alcoholic drinks what in general constitutes a temperate manner of life? What does temperate living involve as to (*a*) kind and quantity of food taken; (*b*) sleep; (*c*) amusements and recreations?

7. In the building up of the body tissues what is the food value of tea and coffee? In what respects may their use become a serious menace to health?

8. What is meant by *narcotics?* Name several. Under what circumstances are narcotics a blessing to mankind? When do they become a curse? Why are liquids containing alcohol included among the narcotics?

9. What is meant by the drug habit? Why is it so seldom overcome? How is it that anyone becomes a victim of the drug habit? Why is instruction in the terrible results of the habitual use of drugs necessary in schools? Under whose direction only should drugs ever be taken? Why so? Why are there such stringent regulations for the sale of opium and its compounds, and of other narcotics?

10. The claim that one's nerves are soothed by use of tobacco is confession of what fact? Give any sufficient reasons for learning to smoke after one is thirty years old. From your knowledge of the growth of the body by cell-division, and of the nature of the protoplasm of the cells, account for the stunting of body and mind in boys from excessive use of tobacco.

11. Why are "soothing sirups" given to infants? Judging from their effects what must they contain? What

is a common constituent of them? What harmful effects may follow their use with infants?

12. What alone constitutes a cure for any ailment? Wherein lies the efficacy in general of the "cures" for headache? What is the objection to an indiscriminate use of headache powders?

13. Preliminary to all medical treatment worthy of the name, and indispensable before administering any remedies, is an understanding of the cause of the ailment — a correct *diagnosis* of the case. Without such knowledge what expectation can there be that the cause of the sickness will be removed and health restored? In the use of "patent medicines," what recognition is there of any need to determine the cause of the ailment? How much consideration is given to the manner of life of the patient?

14. What is true of the competency of most people, young or old, to diagnose ailments and prescribe treatments for themselves? To what extent ordinarily is there any protection to purchasers in having the names of the ingredients of any patent or proprietary medicine printed on the label? What is true of the knowledge of persons generally of the effects of these ingredients? What explanation is there for the widespread use of patent medicines?

GENERAL SCIENCE, AND RIGHT LIVING

1. Under all normal conditions of living what is true of the growth of children day by day and year by year in height, weight, and strength? In these respects at about what age does a *boy* become a *man?*

2. In order to grow in body day by day, increasing in weight and in strength, what are some of the conditions necessary to be observed? For intellectual growth, and for increase in mental capability, what constitutes (*a*) the needed food; (*b*) the exercise required? At about what ages does a person attain full measure of mental powers?

3. It may be assumed as true that something more vital than age or stature marks the distinction between a man and a boy. The change from childhood to manhood or womanhood may very properly be measured by an ability to direct one's self aright in what is thought and said and done. In that case what length of time in a general way is required for a child to grow to be a man or a woman? What are some suitable tests to determine whether a boy is growing to be a man or not? How much change in this respect is likely to be noted in any one day or in several days?

4. The failure of a person to do what he knows should be done by him may be considered evidence of what stage of growth for him? What in a large measure aids anyone to decide whether any particular act in life is right or wrong for him? For how many years may one keep growing in a mastery of himself so that he does what he ought, and does it without being told to do it? If one at all times seeks to do right things, how much need will there be for him to give attention to what ought not to be done?

IV. MATTER AND FORCE

SOME PROPERTIES OF MATTER, AND CHANGES IN MATTER DUE TO FORCE

1. Into a test tube already filled with water, attempt to put considerably more water without causing any overflow. What constitutes a satisfactory "explanation" of the inability to do this?

Our knowledge of the existence of the water, and of the existence of any other portion of *matter*, involves the fact that they "occupy space," and that no two bodies can occupy the same space at the same time. To say that matter is that which occupies space tells what matter is by naming a distinguishing characteristic. This does not in any way imply that scientists themselves have any complete knowledge of the real nature of matter, nor does it mean that there may not exist that which takes up no room, and is therefore not matter. Indeed, the study of Physics is quite as much concerned with that which as *force* (the cause of changes in matter) has itself no material existence.

2. Every portion of matter extends outward from a point within the body in three different directions, giving to the body its dimensions of length, breadth, and thickness. *Extension, impenetrability, form, size,* and *density* are closely related *properties* of matter. Give the definitions for each.

3. Push a book lying upon the table, and note that it can be moved — that it has *mobility*. Now let it alone,

and see if it moves of itself. What is a reasonable inference concerning the ability of a body to move itself? When a body is found moving, what may be assumed as cause of its motion? [In the study of Physics phenomena due to any "life" in matter are not considered. Bodies are supposed to be lifeless.]

Hold a pencil out at arm's length, and then let go of it. When does it stop falling? Infer if it could have stopped itself when falling, all other bodies being out of the way. The tendency of a body when in motion to continue moving, and the inability of a body to set itself in motion, constitute together the characteristic of all matter known as *inertia.* Formulate a definition for this property.

4. Stretch a rubber eraser; then bend it, and then twist it. What holds the particles (*molecules*) of the eraser together, resisting their separation? Are the parts held together alike in nature, or unlike? Define cohesion. What force was applied in these cases to change the form of the eraser? Where a body subjected to any force has its form changed rather than its position, *i.e.*, where it resists being moved, it is said to be under *strain.* Where the body resists being pulled apart it is under *tension;* when twisted, it suffers *torsion;* when bent, *flexion.* When the parts of a body are pressed together it is said to be under a strain of *compression.* Formulate definitions for these four forms of strain.

The force which causes any of these forms of strain in a body is spoken of as a *stress,* regardless of what force it may be. Stress and strain are thus correlative terms, and the use of one of them implies the other.

5. When a rubber eraser is under any strain, what marked tendency as to form becomes at once apparent upon removal of the stress? To what is this recovery of form to be attributed? The property of matter thus made manifest is known as *elasticity*. Formulate a definition for it, being careful to include mention of the force upon which this recovery of form depends.

Gases have no form of their own, but when released from pressure they regain the volume (size) they had before they were compressed. Now re-word the definition for elasticity to make it include the more or less complete recovery of both size and form in bodies when any stress upon them is removed.

6. Try to break a piece of copper or iron wire by pulling upon it, by bending it, and by twisting it. What resists the efforts made? Say the wire has *tenacity*. In what class of bodies (or what state of matter) must tenacity be lacking? Define tenacity as a specific (not general) property of matter.

V. WATER, AND ITS USES

SOME PROPERTIES OF WATER

1. Which of all the things needed to keep us alive causes suffering most quickly when withheld? Which next? What is the price we need to pay ordinarily for either? How do you account for this?

2. Taste water from different glasses, one glass having in it salt, another sugar, another vinegar. Then taste of pure water. What property of pure water is shown?

3. Smell ammonia water cautiously; then pure water. Name another property of pure water.

4. Look at a pencil through glass. Put the pencil in water, and look at it through water. What other property of water is shown? Explain the muddy appearance of some rivers.

5. Name several substances that dissolve readily in water. Name a few that do not. What solvent power has water as compared with other liquids? If water did not dissolve most substances, what would be true (*a*) of the digestibility of our foodstuffs; (*b*) of their taste? Name some substances unsuited for food because they are so slow to dissolve.

6. Pour water into dishes of different shapes, and state the form taken by the water in every case. Why is this? Make a distinction between solid and liquid states of matter.

Grasp a handful of sand. Try to do the same with water, and explain the difference in results. Explain why liquids at rest have a smooth upper surface rather than a rough heaped-up form.

VAPORIZATION AND CONDENSATION

1. What change occurs in the quantity of water (*a*) when a little is left in an open dish exposed to the air for some time; (*b*) when a wet piece of cloth, as a handkerchief, is hung up exposed to the air? After some water has been boiled for a time in an open dish, what is true of the quantity of it?

In all these cases what becomes of the water? At what temperatures does this change of *vaporization* of the water go on most rapidly? Name other conditions that favor a rapid vaporization of water from the earth's surface. Name several sources whence the supply of moisture in the air is maintained. Whence comes the heat?

2. Over the mouth of a test tube in which water is boiling hold an inverted wide-mouthed bottle whose sides are dry and cool. Describe what takes place. What relation is there between the processes of vaporization and *condensation?* What causes condensation of the moisture present in the atmosphere? In what ways (two or more) does this come about?

3. How is it that in some regions of earth a sudden and extreme fall in temperature may cause no precipitation either of rain or snow? What is true of the general character of a region, and its fitness for habitation, where the atmosphere is commonly destitute of moisture? In regions that

are far away from large bodies of water, how do you account for a supply of atmospheric moisture sufficient for an ample rainfall?

4. Describe the difference in conditions that result in the formation of (*a*) dew and rain; (*b*) white frost and snow; (*c*) fog and cloud.



FIG. 18. — Great cloud masses result from the condensation to minute water particles of the water vapor in ascending air currents.

Why is it that *steam* is visible near the mouth of a teakettle of boiling water and disappears a little farther outward? Why is there no appearance of this "steam" close to the outlet?

5. When should a gaseous form of matter be spoken of as a *vapor* rather than as a gas?

HEAT OF VAPORIZATION, AND OF FUSION

1. Take frequent temperature readings as the teacher heats some ice cold water containing small lumps of ice. The water must be stirred continuously with a thermometer, and heated slowly till the ice is melted and the water boils. Record the temperature (*a*) at the beginning; (*b*) from time to time while the ice is melting; (*c*) during the time until the water boils; (*d*) while the boiling water is heated more and more.

2. Observe the temperature of the room as registered by a thermometer. Wet the bulb of the thermometer with alcohol (or water), and wave it back and forth in the air. Observe the lowest temperature it records.

Tie one thickness of cotton cloth about the thermometer bulb, wet it with alcohol, and repeat the test.

What becomes of the alcohol in both cases? Recall by what means the vaporization of liquids has been accomplished before. Give an explanation of the thermometer changes. When vapors are condensed and changed to liquids what is true of this heat of vaporization?

3. Into a hot iron spoon put water a little at a time, and observe what changes occur in the water and in the temperature of the spoon. What becomes of the heat that was in the metal?

What part does vaporization play in the temperature of any region intensely heated by the sun during the day, as during our summer time? What is true of the temperature of land surfaces largely destitute of water when under a summer's sun?

SOLUTION, ABSORPTION, DIFFUSION

1. Make crayon marks on the blackboard, or lead pencil marks on paper. Why does an attempt to jar or shake these off not succeed?

2. Dip a finger into water. Explain why it comes out wet.

3. Let a stream of water from some height fall into a jar of water. Account for the bubbles of air in the jar.

4. Lower into water a rough stone. Why do not all the air bubbles on the surface of the stone rise to the liquid surface?

5. Drop a lump of salt into some water. State what change occurs in it. What force that previously held the parts of the lump together has now been overcome? Where

is the salt now? Get a drop of water from any part of the vessel that does not have salt in it. By what are the particles of salt and water held together? What apparently must be true of the size of the salt particles? How is it that every drop of water has apparently come into contact with a particle of salt without the liquid having been stirred or heated?

6. Evaporate some of the salt *solution* to dryness. Taste any solid left. What is it? Let the rest of the liquid stand in a covered dish till next day and see if any of the salt settles to the bottom. If not, why not? Try to filter out the salt. What is here taught of the size of the particles?

7. Stir a little earth into a tumbler of water and let it stand. Explain what happens. Repeat with kerosene and water, and explain the result. Why does cream rise on milk?

8. Heat gently some water in a test tube. Where does the air that collects on the sides of the tube come from? (Bubbles of steam if formed could not persist in the water below boiling temperature.) Explain how this air was kept in the water.

9. Lay a blotter down upon a drop of ink. What is done to the ink by the blotter? How can this be? Since we say that water dissolves air, why not say that the ink dissolved the blotter, or the blotter dissolved the ink? Give a good definition for solution.

10. Note very carefully the results as the teacher follows out these directions: —

Wet the inside of a clean bottle with a little strong hydrochloric acid, and set the bottle to drain, bottom up. In like manner (perhaps in another part of the room) wet

another bottle inside with strong ammonia water and let it drain.

Both these liquids are solutions of gases in water. The bottles are thus made to contain in one case hydrochloric acid gas and in the other ammonia gas. In both cases these are mixed, of course, with much air. Observe any color or other evidence of the presence of the gases in the bottles.

When these gases combine chemically they form particles of a white solid easily seen. This change can occur *only where there is intimate contact of the gases.*

Now bring the mouths of the bottles together, holding both horizontally. Note the progress of the chemical change, and explain the mixing of the gases as the bottles are held in place.[1]

OSMOSIS IN THE BODY AND IN PLANTS

Watch closely while the teacher sets up the apparatus as directed below, noting the results that manifest themselves through a considerable period of time afterward: — Fill with molasses a "diffusion bulb" that has been thoroughly soaked for a time in hot water, and insert into its mouth a close-fitting rubber stopper through which has been passed a rather long glass tube of small bore. Twist a wire tight around the top of the bulb to prevent any leakage around the stopper. Set the bulb and its tube down into a bottle of water deep

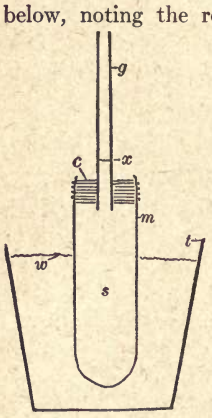


FIG. 19. — Osmosis apparatus for liquids.

[1] The striking change in the substances here is indeed a *phenomenon*. In science any change in matter, however familiar it may be, is considered a phenomenon, and is evidence of the action of some force. All the changes of the preceding experiments of this lesson are illustrations of phenomena.

enough to cover the bulb, and let it hang suspended there[1] till next day when the changes that follow will come up for discussion.

1. Describe the change observed. What is the explanation of it? When liquids mix (intermingle) by passing through porous partitions by reason of their molecular motions alone, the phenomenon is known as *osmosis*. This term covers the mixing of gases in like manner. What must be true of the freedom of molecules to move about, that osmosis, whether of liquids or of gases, can occur? What is done to give solids the necessary molecular freedom for osmosis? What evidence has there been of a greater flow in one direction than in the other? What simple explanation for this may be offered? As the liquid column mounts higher and higher, what sustains it in the tube? What measures the value of this *osmotic pressure?*

2. Some substances in solution (like white of egg, and solutions of starch and of glue) osmose but little if at all. Such substances have been called *colloids,* distinguishing them from substances known as *crystalloids* whose solutions osmose readily.

3. What condition of tissues is necessary that osmosis of gases may take place in the lungs whereby oxygen gets into the blood and carbon dioxide gets out? Discuss in detail this process of interchange of gases in the lungs.

4. What is the great purpose of the various steps in the digestion of food? What is the chief end to be attained in cooking food? What makes up the large bulk of the diges-

[1] A rubber stopper previously slipped on over the upper end of the glass tube makes this suspension easily arranged.

tive fluids? About what per cent of the blood is water? What purposes are served by having this so?

5. Explain somewhat at length how the various cells of the body get their nourishment, and how they get rid of their waste products. When this waste matter gets into the blood, how is it disposed of? Do the red corpuscles of the blood pass through the walls of the blood vessels? What is true of the white corpuscles?

6. What part does the solvent power of water play in the nourishment of plants? What part has osmosis? In the growing plant evaporation from the leaves (*transpiration*) rids the plant of relatively large volumes of its sap water. What part may this have in the rise of sap through growing plants?

STUDY OF A STREAM

1. Mention by name (or locate otherwise) the creek, brook, or river nearest to the school building. How far is it from the school (*a*) by highway; (*b*) by most direct route? Are there fish in its waters? If so, what kinds? If not, why not?

2. What is true of the rate of its current at different places? In general is the current swift or sluggish? How could you determine quite accurately just how swift it is at any point? Why is it not swifter? Account for the direction of its flow.

3. Describe the course of the stream so far as it is known to you, telling whence it comes, the general direction of its flow, and what becomes of its waters. Upon what does

the volume of its waters depend? For how long a time will this stream naturally continue to flow?

4. To what distances up and down have you followed the stream? Which is the right bank (*a*) of this stream; (*b*) of any stream? Describe in a general way the character of country through which it flows, whether hilly, level, broken, or mountainous. Recall any relation between the character of the banks of the stream and the rate of its current. What differences exist in the bed of the stream at different places? How are these accounted for? What explanation is there for any swift and broken current ("rapids")? What significance have places of comparatively still water? What is true of the widths of the stream at different points? What relation has this to the depths at such places?

5. Of how much use in navigation is the stream? Why so? Has it any use for manufacturing? Why? Name other respects in which it is of use.

VALLEY FORMATION, AND SURFACE EROSION

1. From observations you have made of some gentle slope (by field, roadside, railway cut, or earth pile) where the earth is bare and subject to wash by rains, state what relation is apparent between steepness of slope and (*a*) crookedness of the channels cut by the flowing surface waters; (*b*) depths of the cuts? Offer an explanation (*a*) of the crooks and turns in these channels; (*b*) of the greater depths of some cuts than others. What is meant by *erosion* (ē-rō′zhŭn) of soils?

2. Distinguish between a main channel, and its tributaries. Why should there be any tributaries? What is meant by a *divide* between adjacent channels?

3. Make a sketch of some imaginary stream and its tributaries, and by appropriate lettering locate thereon (*a*) the main channel; (*b*) a tributary; (*c*) the mouth of the main stream; (*d*) its source; (*e*) a divide between two



FIG. 20. — Canyon of the Colorado River.

tributaries. Inclose by a continuous dotted line on the sketch what is included in the "water-shed" of the system. What is the meaning of (*a*) river basin; (*b*) river system?

4. How much is included within the limits of a *valley?* How many slopes has it? Explain the absence of streams in so many of the smaller valleys? What various names are given to very small valleys? Why have these valleys never become larger? Account for the existence of valleys in general. How may *hills* have been formed? Where hills of considerable height exist what is likely to be true of the nature of the material of which they are made?

5. Where flowing water makes cuts in the earth, (*a*) upon what factors does the rate of cutting depend; (*b*) which parts of the surface are most readily carried away? What significance is there in the muddiness of some surface waters? Under what conditions will this muddy water become clear? Why is it that streams made up of the surface waters from the hillsides in some parts of the country are clear, and quite free from sediment? What is the relation of this to the fertility of those hillsides? What becomes of much of the soil washed off into streams? What is the inevitable result of the continuance of this action upon (*a*) the fertility of farm lands; (*b*) the surface level of the country?

VI. THE ATMOSPHERE

SOME PROPERTIES AND USES OF AIR

1. Empty a filled bottle of water. What goes into the bottle as the water flows out?

2. Press a bottle mouth down into a jar of water, and over a floating bit of cork. Explain why water fails to enter and fill the bottle.

Repeat, having an outlet through a rubber tube for the air that is in the bottle.

3. By means of a piece of rubber tubing attached to a glass tube that passes through the stopper of a bottle, force into the bottle as much air as possible, and keep it there. What must be true of the condition of the air within the bottle now. Explain how it is possible to force more and more air into the bottle.

Unclasp the delivery tube after putting its outer end under water, and observe what occurs. What must the air particles have done to one another? Explain how it is that water vapor finds place for itself in the atmosphere. What property of air is involved?

4. Through a pipette[1] whose large end reaches down into water in a tightly stoppered bottle, force as much air

[1] Make by heating a piece of glass tubing till sufficiently softened to be easily drawn out into any desired size when removed from the gas flame. Allow it to cool, and break tubing as desired, making use of a sharp-edged file.

as possible from the mouth into the bottle. Withdraw the mouth quickly to one side. Explain the fountain effect.

5. Where about us is air to be found? Attempt to grasp a handful of it. Account for the inability to do this. Point to any air that you see.

6. Look at a pencil through window glass. What property of the glass is manifest? Remove the glass, and look at the pencil through air. What property of air is manifest?

7. What odor has pure air? What taste?

8. What is a chief constituent of air other than oxygen?

9. Name several uses served by air (*a*) when still; (*b*) when in motion as a wind.

10. Write in a column a list of a dozen things you have known the wind to do. Then in a column, and opposite every such act, write adjectives characterizing it, using such words as saucy, tireless, gentle, angry, etc. Mention the various names given to winds by reason of variation in their force (intensity).

11. What are the names given to winds according to the directions whence they blow? Name several ways in which wind directions may be somewhat accurately noted.

12. Tell of the importance of winds to mankind in commerce. In what ways do winds minister to man's comfort and to his discomfort? In what ways do winds affect man's health?

PRESSURE EXERTED BY THE ATMOSPHERE

1. Tie in loose folds some thin sheet rubber over the large end of a thistle tube, making air-tight the rubber covering. Blow into the open end of the tube and observe the rubber. Compare the amount of air within the tube now and before. What must be true of the condition of the air within as compared with the air without the tube? Explain why the rubber is pressed outward.

2. Using the same apparatus, suck some of the air from the tube and observe. Exhaust more of the air, and observe again. Explain why the rubber is now forced inward, and why more in one case than in the other. What relation exists between the density of the air within the tube and its pressure upon the rubber? With the density of the outside air remaining the same, how may the greatest inequality of pressure on the sides of the rubber be secured?

3. Closely fit into a wide-mouthed bottle a rubber stopper through which is passed two glass tubes, one of them long, and the other short and bent at right angles. Let the longer tube extend down into some water in the bottle. Through the short tube blow gently into the bottle and observe the water in the long tube. What change in condition of the air in the bottle results from blowing more and more air in? Why does water rise in the long tube?

What relation exists between the degree of compression of the air in the bottle and the height of the water column? What causes the rising column to come to rest? How long will it remain stationary?

Force water up into the long tube nearly to the top, and close the tube air-tight with one of the fingers, leaving a lit-

tle air in the upper end of it. Remove the mouth from the short tube, and observe the water column. What is now true of the air pressures within and without the bottle? Exhaust some of the air from the bottle through the short tube, and observe the height of the water column. By what is the weight of the water in the long tube sustained?

4.[1] Fill with mercury a glass tube that is at least thirty inches long and closed at one end. Holding the forefinger over the open end, invert the tube and put this open end down under mercury in a dish (a small mortar). Cautiously remove the finger, and observe the upper end of the mercury column. Explain why the mercury column stands in the tube above the mercury level in the dish. Tip the tube back and forth sidewise for short distances, being careful to keep the lower end at all times below the surface of the mercury in the dish. What seems to be true of the space above the mercury in the tube?

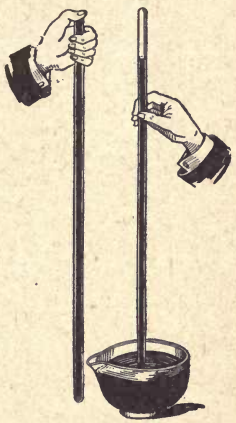


FIG. 21. — A simple barometer.

Measure the distance *vertically upward*, both in inches and in centimeters, from the surface level of the mercury in the dish to the level in the tube. How long will this height remain unchanged? What is true of this difference in levels as the tube is again tipped sidewise? As mercury is 13.6 times heavier than water,

[1] The part of this experiment making use of mercury should be done by the teacher.

calculate what height of water column would be supported by the same atmospheric pressure.

5. If possible make a study of a *mercury barometer*, noting in it (*a*) the mercury cistern and how the air pressure from without reaches the mercury surface; (*b*) the heights of the mercury column from time to time, and from what point this measurement is taken in all cases; (*c*) the provision for reading the height of the mercury column to the fraction of an inch.

What would be the effect of the presence of any air within the tube (*a*) upon a rising barometer column; (*b*) upon a falling column?

APPLICATIONS OF ATMOSPHERIC PRESSURE

1. Tightly close the mouth of a tall bottle with a rubber stopper through which passes a pipette whose small end is inside the bottle. Attach a short piece of rubber tubing to the large end outside the bottle, and with the mouth by repeated efforts exhaust the air from the bottle, pinching the tube together while taking breath. Put the end of the rubber tube under water, and holding the bottle bottom up release the pressure on the rubber tube. Explain the action noted. What causes it to stop?

2. Hold by the bottom a tumbler brimful of water. Press down closely upon the top of it a piece of cardboard, and then carefully invert the tumbler. Remove the hand from the cardboard, and explain why the water does not fall out.

3. Insert one end of a glass tube into water and suck air from the other end. Explain why the water rises in the tube. What is a familiar application of this principle?

Fill a bottle full of water, and with a rubber stopper carrying a long glass tube close the bottle air-tight, with water in the tube above the stopper. Attempt to suck water out of the bottle through the tube, and explain the results. Repeat the experiment, but with the bottle only partly filled with water, *i.e.*, with some air in the bottle. Why are the results so different?

4. Follow very closely the teacher's explanation of the action of both *lift pumps* and *force pumps* as these are illustrated by use of glass models, or by drawings at the blackboard. Then by the use of drawings on your papers write brief descriptions of both kinds of pumps.

5. From explanations of the action of *air pumps* by the teacher, based on the operation of an air pump or on drawings at the board, write a description of your own of their construction and operation. (Use any drawings that may aid in making your description brief and clear.)

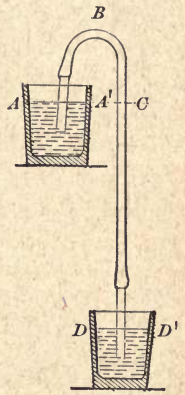


FIG. 22. — The siphon. The lengths of the arms of the siphon are from the surfaces of the liquids at *A* and at *D* to the highest part of the siphon at *B*.

6. Fill with water a glass tube bent for use as a *siphon* (sī'fŏn), one arm of which is only a little longer than the other. Holding a finger over one end so that the water will not run out of the tube, put the short arm of the siphon down into a tumbler filled with water, and then remove the finger. Infer (*a*) what causes the water to rise in the tube above the tumbler top;

(*b*) why the downward pull of gravity on the water in the long arm is greater than in the short arm; (*c*) why water in the tube flows out of the long arm.

Repeat the experiment, but have the outer arm of the siphon dip into water that fills another tumbler. Raise and lower first one of the tumblers and then the other, causing the water to flow back and forth.

Where should measurements be taken to determine the length (*a*) of the short arm of the siphon; (*b*) of the long arm?

7. From the lesson on Respiration recall and restate how the capacity of the chest cavity is increased and how it is diminished in natural breathing. Explain why air goes into the lungs, and why it goes out, making use of such drawings of the chest cavity as may be helpful.

CAUSES OF CHANGE IN ATMOSPHERIC PRESSURE

1. Close a test tube with a rubber stopper, through which passes a glass tube. Invert the tube and hold the end of the glass tube under water. Heat the test tube, and observe what occurs at the mouth of the glass tube. Explain the behavior of the air of the tube. What is true of the density of the remaining air?

Allow the tube to cool with the glass tube still under water, and account for what occurs. What is true of the density of air as it cools?

2. The weight of a cubic foot of air and of the vapor it contains *in grains*, with the barometer at 29 inches, and with the temperature in Fahrenheit degrees, is approximately as follows: —

Degrees F.	When Dry	When Saturated with Water Vapor	Weight of Water Vapor in 1 Cu. Ft. of Saturated Air
0	604.8	604.1	0.553
32	564.9	561.4	2.128
62	532.7	528.9	6.167
102	494.9	461.3	20.979

In the table, what is the relative density (*a*) of dry air and of saturated air at the same temperatures; (*b*) of air whether dry or saturated as the temperature is increased? What is true of the amounts of water vapor held by the air as its temperature is lowered?

3. What must be true of barometer readings (*a*) in a warm moisture-laden atmosphere; (*b*) in a cold dry atmosphere? With a temperature stationary or rising, what is the probable cause of a falling barometer? What is the reasoning that forecasts rainfall when there is any considerable fall in the mercury column of the barometer?

CURRENTS IN THE ATMOSPHERE

1. In the first paragraph under Ventilation, what was true of the relative temperatures of the air in the two chimneys? What will the air in the box do because of these conditions? Explain why the air goes down one chimney and then on through the box. What is true of the temperature of the warmed air after it leaves the chimney?

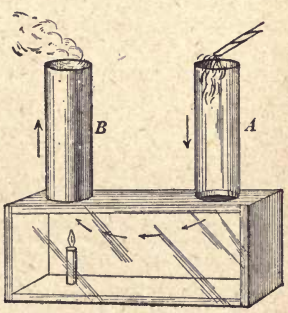


Fig. 23. — Convection currents in air.

Trace its possible course to make a complete round of circulation.

2. Trace the complete circulation made possible when in one region of the country there is a warm moist atmosphere, and in some adjoining section the air is cold and dry. How long will this movement of atmosphere be maintained? In what part of this circuit will the air current be along the earth's surface? Where will this air current cease to exist? Upon what will the velocity of the current largely depend?

3. It may be well to distinguish between different parts of this circulation of atmosphere by limiting the use of the term *wind* to the current along the earth's surface as distinguished from ascending, descending, and upper air currents. Using the term in this way, infer (*a*) where a "wind" originates (springs up); (*b*) where it ends (ceases to be a wind); (*c*) from what direction it will blow.

4. Where air currents are established, and regardless of changes of temperature and of moisture, what will be the effect on barometer readings (*a*) of the upward movement of the atmosphere; (*b*) of the downward movement?

AREAS OF HIGH AND LOW PRESSURE

1. In some parts of the world the sun at noon is directly overhead — is in the *zenith*. At what time of year is there nearest approach to that condition here? What relation is there between the temperature of a region and the *obliquity* (ŏb-lĭk′wĭ-tĭ) of the sun's rays as measured by the angle between them and vertical rays?

2. That portion of the earth where the sun's rays are always vertical, reaches east and west around the globe

across northern South America, central Africa, and southern Asia.

What must be one direct result of a continuous intense heating of the surfaces of the immense water areas of this region — the Torrid Zone? Name three causes that combine to make the barometer readings relatively low along the line where the sun's rays are all the time vertical — the so-called *heat equator*.

3. As the hot moisture-laden air of the region of the heat equator ascends, in what directions other than upward is it likely to move in the upper air? What change will occur in its temperature as it rises? What then becomes true of the amount of moisture this air can hold? What is true of its density as a result of these changes? As this upper air moves from the equator poleward, what becomes true of its elevation above the earth's surface?

4. In moving northward from the equatorial region over land areas of varying *altitude*, as on the continent of North America, in what portion of the continent are these upper air currents likely first to touch ground so that moving along the surface they again become winds? What is likely to be true of the character of any such winds fed by the descent of upper air as regards (*a*) temperature; (*b*) moisture? What other direction than northward will be taken by this atmospheric condition resulting from the downpour of upper air? Why so? What is likely to be true of the barometer readings of the sections of country over which these conditions shall in turn prevail?

5. With descending air currents in any one section of the country, what may reasonably be expected in some adjoining

section if an *equilibrium* of the atmosphere is to be maintained? What conditions of atmosphere in any region are likely to favor the development there of an ascending current? From how many directions will winds blow toward these areas of low pressure? At the center of one of these areas, why is there a "calm," — an absence of all winds?

6. Describe the conditions of atmospheric circulation exhibited in these diagrams: —

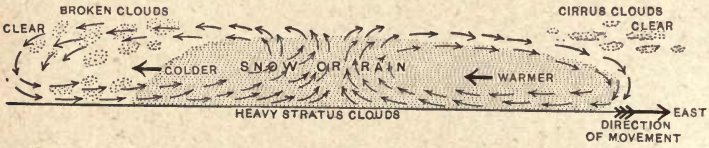


FIG. 24. — The theoretical movement of air in a "low."



FIG. 25. — The theoretical air movements of a "high."

VII. WEATHER AND CLIMATE

WEATHER IN THE AFFAIRS OF MEN

1. When people talk about the weather what are some of the comments usually made in connection with (*a*) temperature; (*b*) atmospheric moisture and precipitation; (*c*) winds; (*d*) state of the sky; (*e*) relation of weather to crops, and trade; (*f*) effect on the health and well-being of people by reason of weather conditions?

2. What in a general way is the relation of temperature (*a*) to latitude; (*b*) to altitude; (*c*) to situations far inland as contrasted with nearness to oceans?

3. Compare conditions in the very cold regions, the torrid, and the temperate, as regards (*a*) the productiveness of the soil; (*b*) the working efficiency of man and of domestic animals.

4. State any relation apparent to you between the changeable weather conditions of the temperate regions of the earth and (*a*) the prosperity of their peoples; (*b*) the variety in their occupations, skill, and productiveness; (*c*) their advancement in learning, and the stability of their governments.

5. In what ways has the human race sought to protect itself against weather changes aside from the kinds of food eaten? In our modern civilization by what further means do we seek to protect ourselves (*a*) from extremes in temperature; (*b*) from exposure incident to travel and out-of-door occupations?

6. In what ways is the manner of life of a people affected (*a*) by the excessive year-round heat of the torrid regions of earth; (*b*) by sudden and extreme weather changes; (*c*) by long-continued wet or dry periods?

7. Of what value to people are *weather forecasts* that are reasonably accurate? Upon what must such predictions be based to have any especial worth? For about how long in advance can reliable forecasts be made?

8. How much is known of the causes of deficient rainfall in any region some years, and of excess in other years? What control over these conditions has man? Explain what the mountain ranges of western United States have to do with any semi-arid conditions to the eastward of them.

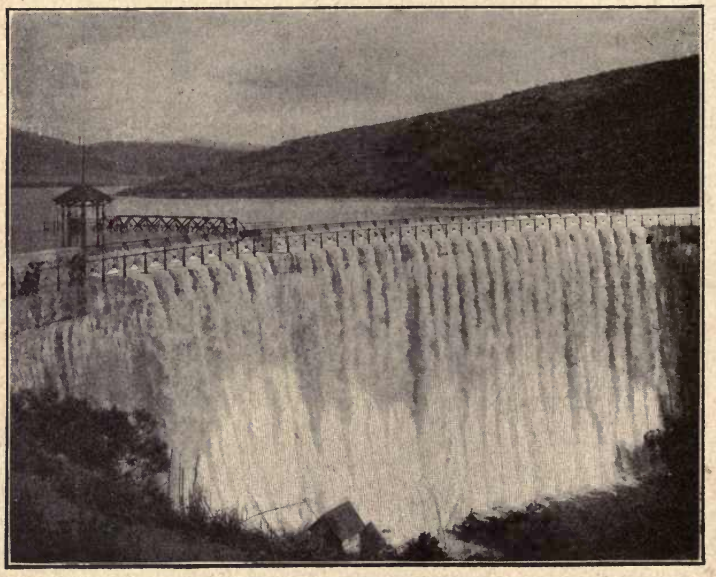


FIG. 26. — An irrigation reservoir.

9. Entirely apart from an ample water supply what must be true of land surfaces to make irrigation for large areas possible? Why is there need of national and state aid in developing irrigated districts? What industries are made possible in such districts? What are the advantages and what the disadvantages of living on irrigated lands?

10. Describe any extensive irrigating system of which you have personal knowledge, or of which you have acquired definite knowledge by reading.

WEATHER AS AFFECTED BY HIGHS AND LOWS

1. From the weather maps of Figures 27, 28, 29,[1] showing the progress of typical storm areas, locate and explain the significance of (*a*) the *isotherms;* (*b*) the *isobars;* (*c*) the wind directions *from a high;* (*d*) the wind directions *into a low;* (*e*) the modification of temperature of a whole region by an advancing high; (*f*) the isotherms "running" with the lows; (*g*) the areas of precipitation. Explain any precipitation in front of an advancing high.

2. Account for wind directions at any point not in accord with the general atmospheric circulation about and into a low, or out from a high. What is the significance (*a*) of the term *cyclone* when applied to a low; (*b*) of anti-cyclone applied to a high? What conditions largely determine the wind *velocities* reported at various points?

[1] Get from the nearest Weather Bureau Station, if possible, some daily Weather Maps of recent date. Ask that those furnished be for successive days during a week or more.



FIG. 27. — Weather map of January 6, 1903.

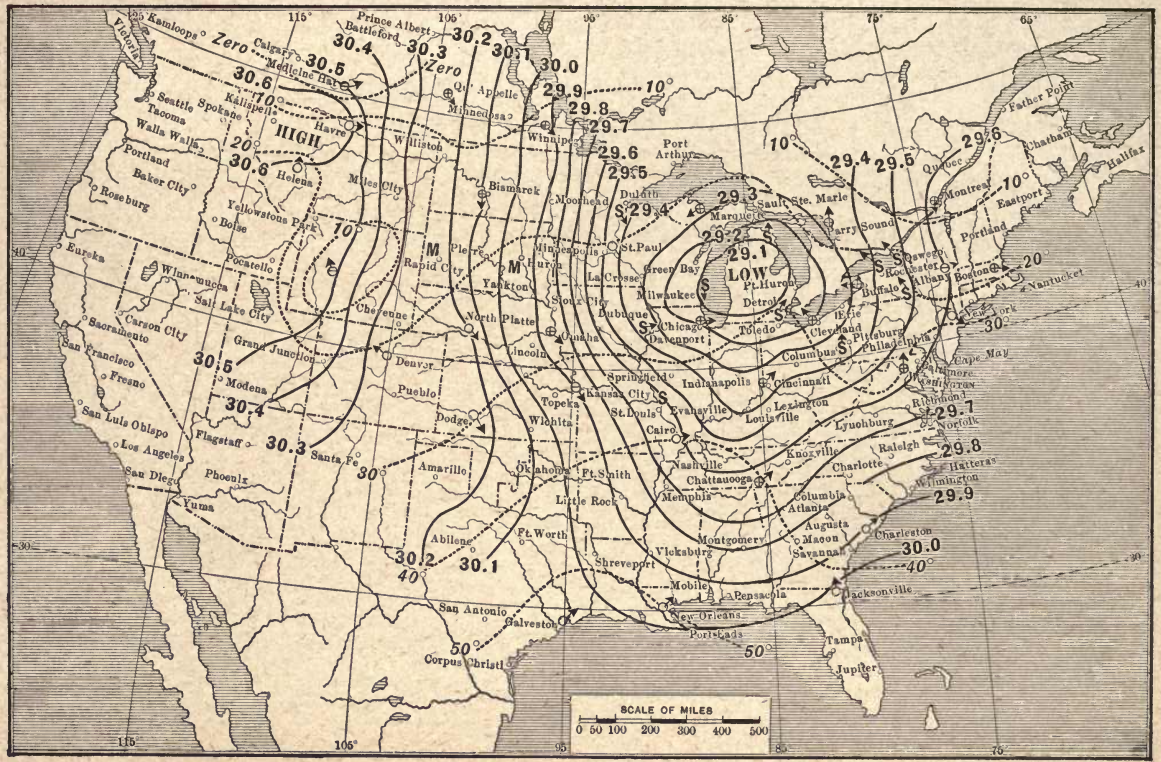


FIG. 28. — Weather map of January 7, 1903.



FIG. 29. — Weather map of January 8, 1903.

THE THERMOMETER

1. Close a test tube filled with cold water with a rubber stopper through which passes a glass tube, and have the water stand above the stopper. Mark the water level in the glass tube by tying a thread around the tube.

Warm the water in the test tube, and observe the effect as shown in the glass tube. Warm more and more, and observe further.

Cool the test tube more and more, and explain any changes.

State the general relationship apparent between change in *temperature* and change in volume. What is meant by the temperature of a body?

2. Put a chemical thermometer having both centigrade (C.) and Fahrenheit (F.) scales into water, and take the readings of the mercury level when stationary in both C. and F. degrees. (Estimate any fraction of a degree in either case as *tenths* rather than *halves*, and *quarters*, and use decimals rather than common fractions in writing results.)

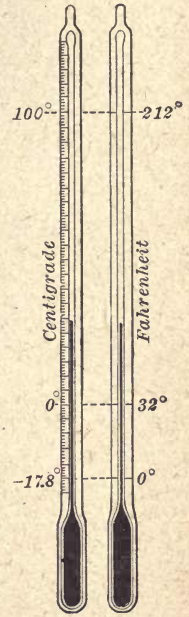


FIG. 30. — Fahrenheit and centigrade scales in thermometers.

Note how many spaces of the Fahrenheit scale the 0° F. is below 0° C. (the place where the mercury level stands when the thermometer is in freezing water). The temperature of the water is how many F. degrees above the zero of the C. reading? Calculate the number of F. degrees (spaces) to which one C. degree of the thermometer stem is equal. (Carry the division out

two decimal places.) Note how this compares with the value $\frac{9}{5}$ (1.8).

3. Note on each scale how many degree-spaces there are between the levels of the mercury when in freezing water, and when in boiling water. Whence comes the $\frac{9}{5}$ used above? State how to change readings of centigrade scale into Fahrenheit readings, explaining why 32° is added to the reduction value found.

4. State how the Fahrenheit readings may be changed into centigrade, and why 32° must now be subtracted before the reduction.

TEMPERATURE RECORDS[1]

1. Take the temperature readings called for in the blank forms below, and record the same at the time taken. Let these observations be made daily during one week only in each succeeding calendar month throughout the school year.

	9:00	12:00	1:00	4:00
Monday	 °	 °	 °	 °
Tuesday	 °	 °	 °	 °
Wednesday	 °	 °	 °	 °
Thursday	 °	 °	 °	 °
Friday	 °	 °	 °	 °
Average	 °	 °	 °	 °

[1] Lessons requiring the keeping of records where data are to be gained by observation through considerable periods of time must be assigned sufficiently long in advance. It is unlikely that too great emphasis will be placed upon the educational value of sustained efforts to accumulate and classify facts. Such facts demand in themselves correct interpretation, and call for keenness of discrimination in relative values. There is cultivated that desirable mental attitude which seeks the truth at every step, and demands the facts before passing judgment. However important the facts of such lessons, their manner of acquisition and of use may be of even greater worth educationally.

2. Note if the daily temperature changes appear to be repeated over and over. Explain the cause of such changes. Why are the midday temperatures highest?



FIG. 31. — Temperature records.

3. Transfer the *averages* found above to another tabulated form, thus: —

	9:00	12:00	1:00	4:00
September				
October				
November				
December				
January				
etc.				

4. At the end of each semester, and at the end of the school year, note the seasonal changes *as shown in the twelve o'clock averages*. Seek to account for them.

SOLAR HEATING

1. Set the insolation apparatus [1] in a south window and so adjust it that a beam of sunlight, passing through the box and falling upon a sheet of paper lying horizontal, shows the narrowest outlines of the box walls.

2. Measure the area of the paper covered by the sunbeam that gets through the box, and tabulate the results [2] called for in the form below: —

DAY	DATE	9:00 (A.M.)	12:00 (NOON)	4:00 (P.M.)	OBLIQUITY [3] AT 12:00 NOON	TIME OF HIGHEST TEMPERATURE OF DAY
Monday...		..sq. in.	..sq. in.	..sq. in.	deg.	
Tuesday...		..sq. in.	..sq. in.	..sq. in.	deg.	
Wednesday		..sq. in.	..sq. in.	..sq. in.	deg.	
Thursday..		..sq. in.	..sq. in.	..sq. in.	deg.	
Friday....		..sq. in.	..sq. in.	..sq. in.	deg.	
Average						

[1] A "breakfast food" carton with both ends removed serves the purpose well. To a block of wood sufficiently large and heavy to serve as a base, tack a strip of wood for an upright; to this attach the carton in such a manner that it turns readily in a vertical plane. Turn the whole apparatus sidewise, and the carton up and down, to get the narrowest possible shadow of the walls of the carton.

[2] See footnote of lesson on Temperature Records.

[3] With a *protractor* measure the angle between the edge of the upright when vertical and the upper edge of the box as it stands properly adjusted.

3. Repeat these observations for one week at a time, and at about the same dates every calendar month throughout a school year. Transfer the "averages" for each week of observation to a second table as below. Only the data by months need be preserved in the notebooks.

Month	9:00	12:00	4:00	Obliquity	Hottest at
September....	...sq. in.	...sq. in.	...sq. in.	deg.	
October.....	...sq. in.	...sq. in.	...sq. in.	deg.	
November....	...sq. in.	...sq. in.	...sq. in.	deg.	
(etc., for the whole school year.)					

4. With practically the same amount of heat (and light) getting through the box at different hours, what is the

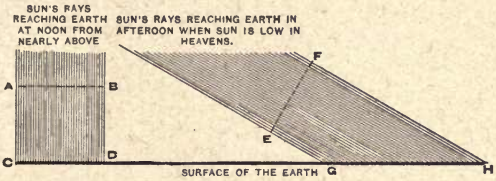


Fig. 32. — Difference in heat intensity of sunlight at different degrees of obliquity.

relation between the area covered by the beam of sunlight and the heating effect of that same beam?

5. State what is noted in the monthly averages concerning changes in heat intensity (*a*) through the day; (*b*) from month to month by seasons.

6. State the relation apparent between obliquity of rays and seasonal changes. Account for this.

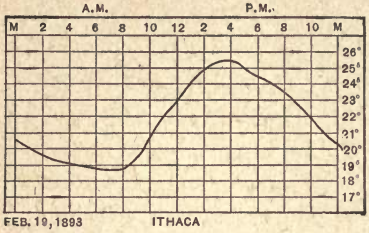


FIG. 33. — Range in temperature during twenty-four hours.

7. Attempt an explanation of the fact that the highest temperature of the day comes later than noon, which is the time of greatest solar heating.[1]

8. Why is it warmer at sunset than at sunrise?

9. Why is it that in northern latitudes the coldest weather is likely to be in January and February rather than in December?

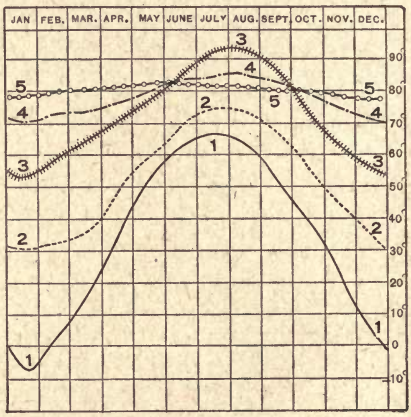


FIG. 34. — Range of temperature during a year for five places having very different climatic conditions. The influence of the oceanic waters of the Tropics is seen in 4 and 5.

[1] It may be possible to make more clear the cumulative heating by day, and throughout a summer, by use of several dishes of different capacity and a vessel of water. The gain and the loss of heat per hour at the place where the observer is stationed on the earth may be represented by quantities of water added to or taken from an original volume in the vessel. The hourly losses by radiation from the earth through a 24-hour period may be considered as approximately the same for any observer. The gain in heat per hour increases up to noon, and then decreases, although for some time after the noon hour *the gain per hour exceeds the loss*.

GENERAL WEATHER RECORD [1]

1. As assigned by the teacher, collect and tabulate the data called for below: —

DATE	TEMPERATURE	PRESSURE (NOTE 1)	WIND DIRECTION (NOTE 2)	AMOUNT OF PRECIPITATION (NOTE 3)	STATE OF SKY [2]
.....	°	in.		in.	
.....	°	in.		in.	
.....	°	in.		in.	
.....	°	in.		in.	
.....	°	in.		in.	
Average	°	in.	(Prevailing wind)	(Total)	(Number of clear days)

2. From the data gathered above, and from the tabulated averages and totals, seek to discover: —

(*a*) The prevailing wind characteristic of any season.

(*b*) The relative amount of precipitation by months and by seasons.

(*c*) Any seasonal round of clear and stormy weather.

(*d*) The temperature ranges and averages for the different seasons.

[1] See footnote of lesson on Temperature Records.

[2] By use of a circle (○), a clear, partly cloudy, or overcast sky may be shown by the degree of shading; an inclosed R = rain, and an S = snow.

Note 1. Some one in the community may have a barometer from which readings can be taken in case the school does not possess its own instrument. If necessary, omit the pressure readings, as well as (*f*) and (*h*).

Note 2. A sufficiently good weather vane may be made and mounted on the schoolhouse by any local mechanic, or by one of the older pupils.

Note 3. Where a rain-gauge (gāj) is not available, a tin can with straight sides (such as a large-size baking-powder can) may be set into a light framework to keep it from being blown away. Put the can out in the open away from trees and buildings. Using a foot rule graduated to 16ths of an inch, measure the depth of water in the can, always holding the rule vertical.

(*e*) Any apparent relation between wind direction, temperature, and rainfall.

(*f*) The relation of barometric fluctuations to weather changes.

(*g*) Any relation between wind direction and state of the sky.

(*h*) Temperature and barometric changes during the passing of a low.

3. From the data accumulated at the various Weather Bureau Stations since the establishment of the U. S. Weather Service in 1870, state what appears to be true of: —

(*a*) Any relation between the weather and "changes in the moon," *i.e.*, changes in its phases.

(*b*) Accuracy in any detailed weather forecasts for a year ahead.

(*c*) The recurrence of approximately the same changes of weather for recurring seasons.

VIII. AT OUR HOMES[1]

ROOMS OF THE HOUSE, AND THEIR FURNISHINGS

(a) *The Kitchen*

1. What is the relative use of the kitchen and of the other rooms of the house during the day? Why is it best not to have the kitchen a large room? What is a good size for it? Using a scale of $\frac{1}{8}$ inch = one foot, represent on your paper a desirable size and form for a kitchen.

2. Name some of the kinds of work carried on in a kitchen in connection with the weekly routine of household duties.

3. State what economies are possible in the purchase and storage of coal for household use. Name various kinds of coal, and tell their relative fuel values. What special care should be given the kitchen coal stove (or range)? What may be done to keep fire overnight in it? Tell how to build a fire in the stove (or range), and how to avoid waste of coal in the ashes.

4. About what is the cost of a gas (or gasoline) range? What is the cost of gas (or of gasoline)? In what ways may there be waste in the use of gas in the kitchen? Explain the

[1] While much that is required in these lessons on the home may be matter of common knowledge to the pupils generally, it is nevertheless urged that there be considerable discussion in detail of household economies and household management. However, any mere statement of the facts required by these lessons is far less important than the establishment of wholesome ideals of a simple manner of living, and a realization of the possibilities of a modern American home.

economy of a fireless cooker where gas is used for fuel. Name several advantages in the use for fuel (*a*) of coal; (*b*) of gas.

5. Of the kitchen sink tell (*a*) the kind and size desirable, and its cost; (*b*) the purpose of a trap for it; (*c*) how to keep the waste pipe from becoming clogged, and how to clean

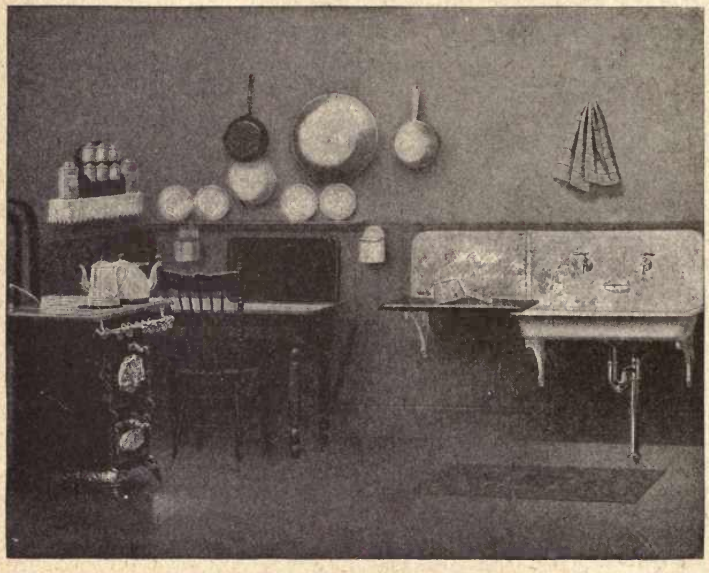


FIG. 35. — Kitchen furnishings.

it from time to time. What is the cost of water in your town for household uses? What are some advantages in the use of cistern water? Name some conveniences to be kept at or near the sink. Why is it better to have open plumbing (pipes exposed) than to have the pipes inside partitions or cupboards?

6. About what is the cost of a kitchen table (or kitchen cabinet)? What conveniences should the table (or cabinet) provide? What kind of a top should the kitchen table have?

7. What need is there of doors for kitchen cupboards? Give a list of the dishes and utensils likely to be kept in a kitchen cupboard.

8. What are the objections to a soft wood floor for the kitchen? Why not have painted floors? What care should be given oiled hardwood floors? State objections to having any floor covering. What is the cost of linoleum? What should be done from time to time to keep the linoleum impervious to water?

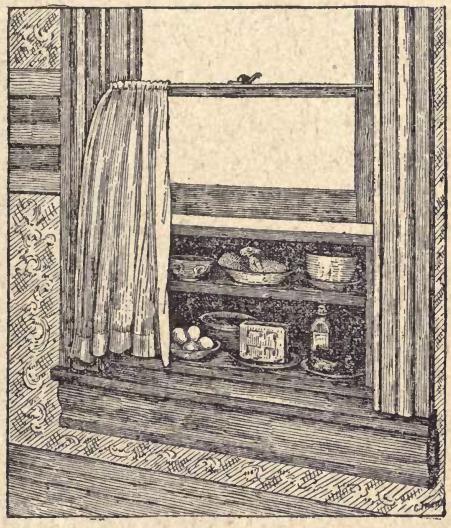


FIG. 36. — Food may be kept in a box just outside the pantry window.

9. What are various finishes for kitchen walls? Discuss their relative cost, and their other merits?

10. Why should there be screens at the kitchen windows? Why remove and store the screens during the winter?

11. What are the advantages in having a separate room for a kitchen pantry? Why have cupboards in it? Why have a window?

12. Name several considerations that influence the choice of a position for the refrigerator for household uses. State the special care that should be given it.

13. Make a floor plan, drawn to a scale, showing the relation of the kitchen to (*a*) back yard and back porch; (*b*) basement; (*c*) dining room; (*d*) pantry. (Make the arrangement of rooms such that the paths most frequently traveled to and from the kitchen range shall be the shortest distances.)

(b) *The Dining Room*

1. What is a usual size and form for the dining room? What furnishings are needed for it? What is a satisfactory floor covering for the dining room?

2. Discuss (*a*) the dining room table — its material, cost, and the proper care of it; (*b*) the kind and cost of dining room chairs; (*c*) the need of a sideboard, and its cost; (*d*) the advantages of a "built-in" china closet.

3. When the breakfast table is "set" for five, (*a*) what are suitable dishes and tableware, and how are these to be arranged? Name some foods ("dishes") for a balanced "two-course dinner."

4. What care should be given the dining room daily? What objections are there to eating in the kitchen?

(c) *Bathroom*

1. Where with reference to other rooms may the bathroom be (*a*) in a one-story house; (*b*) in a two-story house? What kind of wall is desirable? How may hot water be provided for the bathroom?



FIG. 37. — The breakfast table.

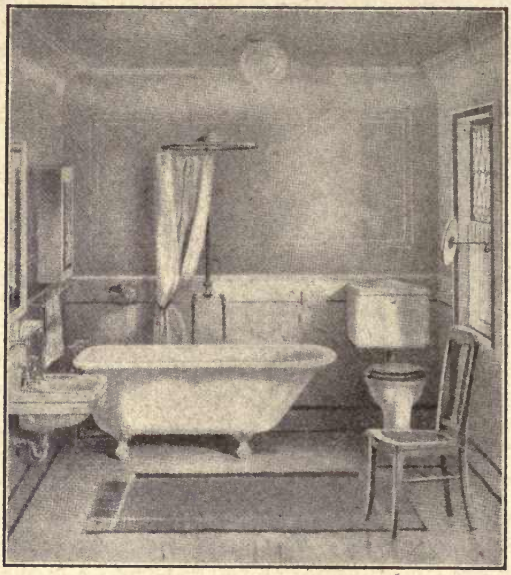


FIG. 38. — Furnishings of a bathroom.

(d) *Sleeping Rooms*

1. Where usually are the sleeping rooms in a house? Why may it be desirable to have a sleeping room downstairs? What is a good size for a sleeping room? What furniture is desirable other than bed, couch, or cot? Mention desirable conditions as to (*a*) windows; (*b*) closets; (*c*) floor covering.

(e) *Living Room*

1. What is the advantage of a hall or vestibule leading into the general living room? Discuss the cost, construction, and size of a desirable kind of library table, and various provisions for artificial light to use with it. Describe some desirable

kinds of bookcases, and make a list of some good books for the home bookcase. Make a list of other furnishings, such as chairs, rugs, etc., and give their probable cost.

(f) *Basement*

1. To what use is a basement commonly put? What is its value in the matters of health, and of warmth for the rooms above? How may it be made rat-proof?

2. Name several kinds of heating plants. So far as possible tell something definite (*a*) of their relative cost; (*b*) of their period of usefulness; (*c*) of their expense of maintenance. Why is there need of a separate room for coal? How may the dust be lessened when coal is handled?

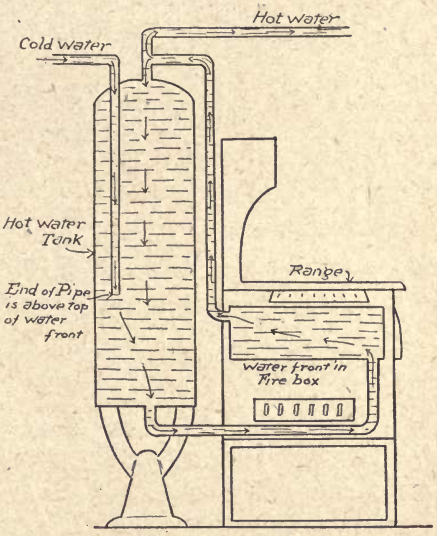


FIG. 39. — Hot water from the kitchen range.

3. Why is it well to have the laundry in the basement? Name desirable furnishings and conveniences for it. What other place may there be in the house for drying clothes indoors in stormy weather?

4. Copy the diagram given, and by use of arrows show how from a "water-front" in the kitchen range hot water may

be provided for the kitchen sink, a bathroom upstairs, and a laundry in the basement.

5. Make a diagram showing a *hot water plant* in the basement, with radiators for one room each on the first and second floors, and an overflow tank. What special care is necessary in the location of pipes, and in plans for their drainage?

THE COST OF LIVING

(a) *Food*

1. About what is the cost of cereals (sē′rē̆-ălz) per package? This is about how much per pound? Tell the manner of cooking and serving them. What is the economy (*a*) of buying them in bulk; (*b*) of cooking them with a fire in use for other purposes? What range of choice is there in "breakfast foods"? Why is it wise to make use of different kinds of grains from time to time? How do the nutritive values of the cereals compare with one another and with meat?

2. About what is the cost of eggs in summer and in winter? How is the storage of eggs in quantity at home accomplished?

3. About what is the cost of coffee per pound? What is the manner of its preparation for table use? About how many cups of drink are made from a pound of it? What limitations in its use as a drink should be observed by adults and by children?

4. What are desirable foods for breakfast? What is true of the nutritive value of fruits? What are reasons other than cost for not having meat and potatoes for breakfast?

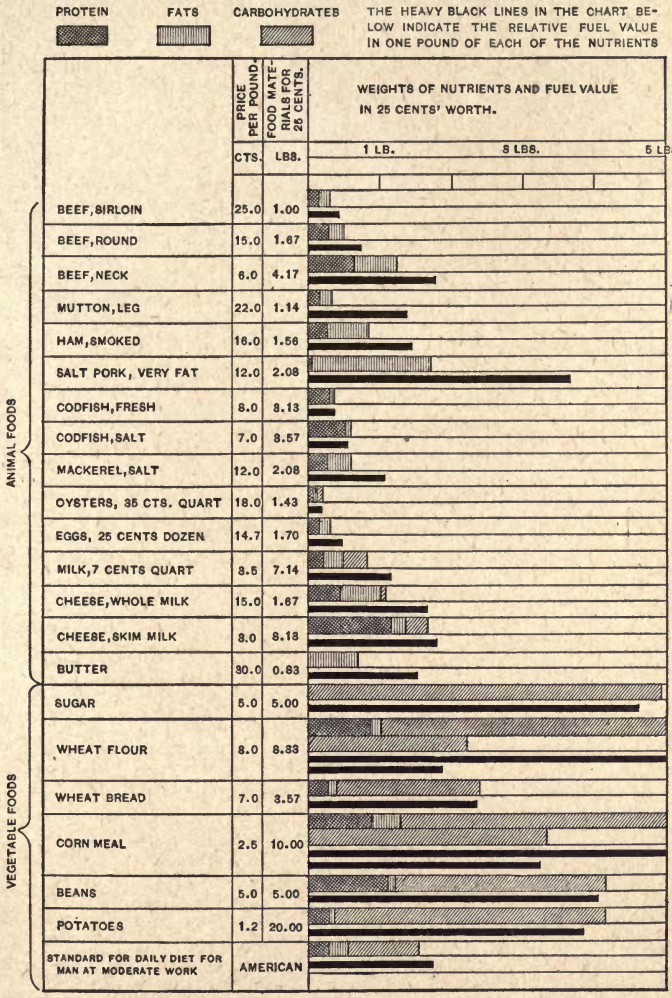


FIG. 40. — The relative values of foodstuffs.

5. About what is the usual cost of potatoes, fall and spring? What are necessary conditions for their storage in quantity in the home? Name ways of preparing them for table use (*a*) for the sake of variety; (*b*) for purposes of economy; (*c*) with reference to the season.

6. What are the prevailing prices of different cuts of beefsteak? What are their relative nutritive values? How should steak be cooked, and why so? What is the relative cost of steak, and of meat for boiling? What is their relative value as foods? What cooking procedure in the boiling of meat gives best results? What management will save fuel? What is the manner of preparation of soup, and what is its food value?

7. About what is the cost of butter per pound, and of bread per loaf? What economies are possible in the use of butter? Discuss substitutes for butter in cooking — their food value, and their wholesomeness.

8. Give the cost of various kinds of garden stuff in season, — as corn, peas, string beans, asparagus, rhubarb, beets, tomatoes, radish, lettuce, cabbage. What table variety may be had in canned vegetables? What is their usual cost per can? What is the relative nutritive value of canned and fresh vegetables? Discuss the relative cost of home canned goods and the factory product.

9. Name various forms of dessert in common use, and give their relative cost.

10. Mention the various dishes in common use for supper, their relative cost, and their wholesomeness.

(b) *Clothing*

1. Name the two chief economic ends in view in the purchase of clothing. By what is one to be guided in judgment as to (*a*) real values in clothing; (*b*) wearing quality? What general rule is to be followed in making purchases because articles are "cheap"? What advantage is there in buying from reputable firms with well-established business standing?

2. What is true of the cost of the same articles (as of suits and millinery) "in season" and "out of season"? What differences in the cost of clothing for the year may result (*a*) from purchases at favorable times; (*b*) from wise selections as to service?

3. Discuss the extent of economies possible through the making of garments at home. What is the value in the home of a knowledge (*a*) of dressmaking; (*b*) of millinery? How, where, and when is this knowledge to be gained?

4. Discuss extravagances (*a*) from extremes in fashion; (*b*) from choice of what is not suited to intended uses; (*c*) from lack of care in wearing, or in storage.

5. Make lists (several items each) of articles that belong in the class (*a*) of things which must be provided for comfort and well-being; (*b*) of luxuries, whether wholesome in influence or not.

6. What constitutes a good standard in dress for anyone to follow? To what extent shall fashion (the prevailing mode) be followed by anyone?

(c) *Rents*

1. Name many advantages from ownership of one's home.

2. What items are to be calculated in the cost of owning

one's home in addition to (*a*) interest on sum invested; (*b*) insurance; (*c*) repairs (on an average) every year; (*d*) taxes; (*e*) depreciation in property through use?

3. Name the several factors entering into a calculation of rental values.

(d) *Other Items in the Cost of Living*

1. Name various furnishings of homes not before mentioned.

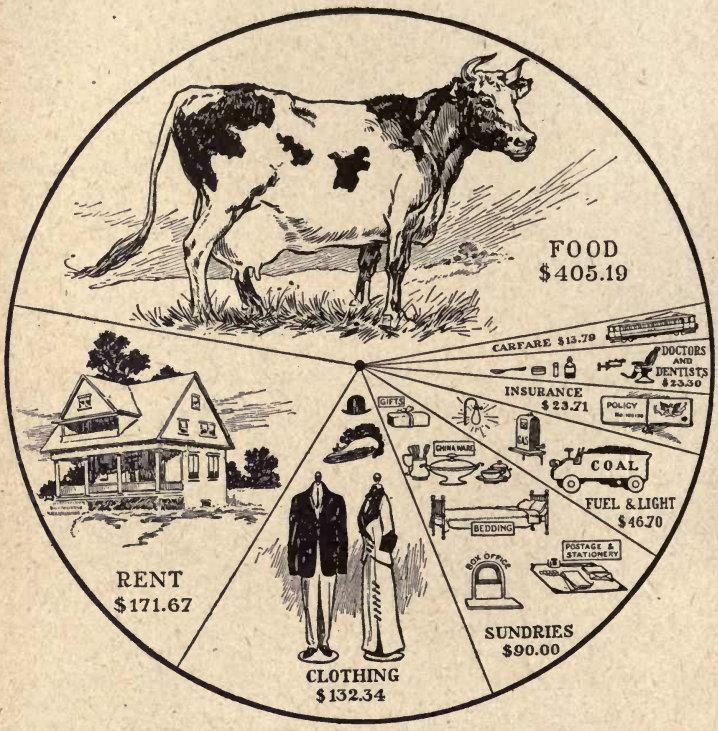


FIG. 41. — A division of the family income. Note the items, and their relative values. What are the savings from an income of $1000?

2. Aside from bills for physician, nurse, and medicines, what are the economic reasons for keeping in good health?

3. What are arguments to warrant expenditures for schools and churches in a community?

4. What is the cost (*a*) of a telephone; (*b*) of electric lights; (*c*) of city water; (*d*) of a daily newspaper?

5. Why is it necessary to levy and collect taxes? For what are such moneys to be spent? Upon what basis is anyone's share of taxes to be determined?

6. What argument is there for including some outlay for amusements in the cost of living? What is a safe standard





FIG. 42. — Wholesome exercise, and great sport.

whereby to judge if any form of so-called amusement is wholesome and fit to indulge in? What (relatively) need be the amount set aside to spend for amusements? Why so?

FIRES, AND BURNS

1. Recall from the lesson on Combustion the relative ease with which kerosene and gasoline ignited, and restate the reason for it.

2. What is meant by (*a*) explosive vapors; (*b*) inflammable gases? Under what conditions will explosions of gases occur? Explain the destructiveness of an explosion of gas. Why oftentimes is there an instant spread of fire accompanying the explosion? Why not use water to extinguish burning oil? What material likely to be at hand in the kitchen may be used?

3. What, as a physician sees it, is the nature of *burns?* What is the usual treatment for them? What is a blister? How proceed to drain out the fluid of a blister?

4. Why are results so likely to be fatal when a large area of the body surface is seriously burned? What treatment will allay the torment from the irritated nerve ends of the burned area?

5. What is meant by internal burns, and why are they likely to prove fatal? What is meant by being suffocated by smoke? What is a wise precaution when compelled to grope one's way through smoke?

6. Explain the explosion when kerosene is poured upon hot coals in a stove. What precautions should be taken when using gasoline at home to clean clothing? In case one's clothing catches fire at any time, why is it usually better (*a*) not to run; (*b*) not to stand erect?

7. When may illuminating gas at the kitchen range become a source of danger? What danger is ever present in

the use of gas lights? Wherein is there possible danger from putting fresh coal into the stove or the furnace just before going to bed? What is a wise precaution to take?

8. What material is used in making the heads of friction matches? Explain why they ignite from friction. When may their ignition be spontaneous? For what reason other than danger in their use is the manufacture and sale of matches containing yellow phosphorus objectionable? What is the nature of safety matches?

9. What is meant by "defective wiring" which is said to be the cause of so many losses by fire? Why are cigar stubs thrown aside peculiarly dangerous as sources of fire?

10. Discuss the nature of some one of the many kinds of *fire extinguishers* on the market. Under what circumstances may these be of large service? Before going to bed in a strange hotel, what is a wise course to take for safety in case there should be a fire during the night?

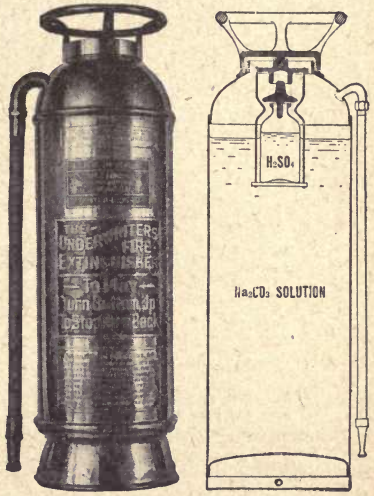


FIG. 43. — A portable fire extinguisher.

11. About how much is the insurance charge for three years on a dwelling and household goods to the amount say of three thousand dollars? Why is the cost so

great? To about what per cent only of the real valuation should property be insured?

12. From the bulletins of the State Fire Warden and the regulations of local fire officials concerning prevention of fires, gather and be able to restate understandingly some of the warnings and requirements as to (*a*) the accumulation of rubbish, and the starting of fires in dry weather; (*b*) the care of matches and of inflammable liquids.

ACCIDENTS OTHER THAN BURNS

1. What is the danger from any slight wound where the skin is cut or torn? What is the chief value of the "first aid" bandages and treatments on the battlefield? Explain the festering of slivers under the skin.

2. What is believed to be one of the offices of the *white corpuscles* in the healing of wounds? What is generally true of the chance for recovery from wounds, or from surgical operations, of persons who are users of alcoholic drinks? Why is this?

3. Where poison has been swallowed, what can be given (*a*) as an *emetic* that the stomach be freed of the poison before it can be absorbed; (*b*) to hinder absorption, and lessen any harmful action on the stomach walls? What should be an enforced rule of every household as to (*a*) place for keeping poisons of any sort in the home; (*b*) labels on bottles and packages of poisonous substances?

4. Mention some of the ways in which street railway managers ask the coöperation of parents and of the traveling public in avoiding accidents. Why must efforts in this respect be made year after year?

In which direction should one face in alighting from a street car? Why is there less likelihood of being thrown when this rule is observed? Which hand should be free to grasp the railing (*a*) when mounting a car; (*b*) when dismounting?

5. What in general is meant by the "safety first" crusade in the industries and in transportation? When are employers of labor justly held liable for accidents to employees? Why is there need of State Inspectors for shops, mills, factories, mines, and all places where labor is largely employed? What are the provisions in your community (if any) for fire escapes on buildings?

6. Why should we condemn a person who recklessly imperils the lives of others as, for instance, one who rocks a boat or in a crowded house gives an alarm of fire "just for fun"? What is meant by "criminal negligence" on the part of a person, business firm, or corporation?

7. What are the tests for fitness (*a*) of engineers of railway locomotives; (*b*) of drivers of automobiles? Who only are allowed to run stationary engines? What ends might be attained by a system of licensing automobile drivers?

8. Discuss the effect on the life and usefulness of a man from the loss of one leg by accident when a boy.

IX. HOUSEHOLD CHEMISTRY

A REVIEW OF SOME CHEMICAL CHANGES

1. So common are chemical changes in everyday life, and so important are these to our well-being and comfort, that it will be profitable to recall some already studied in connection with others more or less familiar in home affairs.

What in general is the nature of the chemical change that occurs in stoves and furnaces in warming our houses? What explanation is there for the heat produced in our bodies? What are the products of the oxidation (*a*) of carbon; (*b*) of hydrogen?

2. How is it that low temperatures, lack of moisture, use of preservatives, and the common processes of canning, hinder or prevent the decay of organic foodstuffs? Name some preservatives of foods that are (*a*) wholesome; (*b*) prohibited because they may be harmful.

3. What is the significance of the term *fermentation?* What is the general purpose of the changes in the processes of digestion? Into what stage of chemical change in foods does fermentation lead if unchecked? What in some cases is the nature of the ailment called indigestion? Why in the fermentation of cider to make vinegar, and in the souring of milk, does the increase of acid cease after a time? Explain the destructive action on the teeth of decaying food

lodged between them? What is the nature of the yeast used in bread-making? What is secured through its use? What effect on the yeast has baking the bread?

4. Where soil is open and porous enough for free access of the oxygen of the air, and at the same time sufficiently moist, what chemical changes favorable to plant growth may occur (*a*) in the *humus* of the soil; (*b*) through the agency of nitrogen-fixing bacteria?

5. What very largely is the "dust" that accumulates on the floors and furnishings of our homes? Aside from its irritating effects on the air-passages and in the lungs, what positive danger is there in breathing it? Where besides in our homes is there danger from breathing dust? What is meant by infection? What diseases ordinarily find their way into the body as germs in the air we breathe?



FIG. 44. — Use a damp cloth, or oiled rag, when dusting.

6. What precautions should be taken to avoid filling the air of rooms with dust when sweeping and when dusting? What adds to the dust nuisance in schoolrooms? What is a common ailment of workers in factories where the air is filled with dust from wood, metal, or cloth?

7. What is the active chemical agent in the *hypochlorite of lime* (and "bleaching powder") used to purify the water supply in city water systems, the soiled clothing from persons sick with infectious diseases, and the air of cellars and basements not kept well ventilated? Name several other disinfectants whose value lies in their chemical action upon disease germs.

THE CHEMISTRY OF CLEANING

1. For scrubbing floors, washing windows and table dishes, and for toilet and laundry purposes, soap is employed to an extent that has led to the statement that the civilization of a nation may be judged by the amount of soap its people use.

What in general is true of dissolving oils and fats in water, either cold or warm? What is the nature of butter? In what size of particles must its material be when scattered through milk? Ascertain the meaning of the term *emulsion*, and show how it applies to milk.

2. What is a common effect upon the skin of the use of laundry soap? Test some strong soap solution with a strip of red litmus paper. If it is turned blue, the soap solution is said to have an *alkaline reaction* (or alkaline effect). Determine by use of litmus paper whether laundry soap or toilet soap is more alkaline. What should be true of toilet soaps with regard to an excess of alkali? Ascertain the nature of (*a*) scouring soaps; (*b*) "sapolio."

3. Why is "hard water" objectionable for toilet and laundry purposes? Why is cistern water more satisfactory? Why is not cistern water available for household purposes everywhere? Where "soft water" is not available for

laundry use, what very commonly is done before making use of soap in washing clothes? Test with litmus paper a solution of any washing powder at hand to determine its nature.

4. From reference books, or other sources, ascertain what to do in order to remove from cloth (*a*) spots of common ink; (*b*) coffee stains; (*c*) paint spots; (*d*) grass stains.

5. How may varnished surfaces, whether polished or waxed, be cleaned without harm to them? How is tarnish removed from metals, such as silverware? How do you account for the blackening of silverware (*a*) by eggs; (*b*) by contact with rubber?

6. Watch very closely the *bleaching* effect on small pieces of cheap calico, and upon stains on white goods, when these are dipped repeatedly into a solution of bleaching powder to which strong vinegar is added. Notice the odor of the bleaching powder. What is the chemical agent active in the bleaching?

ACIDS, BASES, AND SALTS

1. Making use of small strips of litmus paper test the effect on it of vinegar and of fruit juices (as lemon, orange, grapefruit, cherries, etc.); of ammonia water, limewater, and drinking water; and of solutions of baking soda, washing soda, borax, soap, and common salt. Arrange these substances in columns under the headings *acid*, *alkaline*, and *neutral*, according as the litmus paper is turned red, or blue, or is unaffected in color.

To the list as above add a half dozen or more tests of other solutions.

2. Follow very closely the results as the teacher carries out the following directions: — To a solution of baking soda in an evaporating dish add drop by drop some dilute hydrochloric acid (HCl) till, as the solution is stirred thoroughly, it does not affect the color of litmus paper, *i.e.*, till it is *neutralized.* If too much acid is added at any time, more of the soda solution may be added drop by drop. When the solution becomes neutral, evaporate it to dryness, heating till no more vapors pass off. Identify the solid that remains by tasting it.

SOME CARBONATES

1. In the lesson on Combustion what was discovered regarding the effect of the expired breath upon limewater (CaO_2H_2)? What was the explanation of the change in its appearance? The *precipitate* (the solid formed as result of chemical change) is calcium carbonate ($CaCO_3$).

2. Force air out from the lungs through a glass tube that reaches down into 10 c.c. of limewater in a test tube, and continue until the limewater becomes clear as at first. The solid particles of the carbonate of "lime" apparently dissolve. Test the liquid with litmus paper to determine its nature.

To explain what has occurred, it may be supposed that carbon dioxide combines with the water as shown in the equation $CO_2 + H_2O \rightarrow H_2CO_3$ (carbonic acid), and this in turn with the limewater thus: — $CaO_2H_2 + H_2CO_3 \rightarrow H_2O + CaCO_3$. But when an excess of H_2CO_3 has been formed by reason of continued breathing of CO_2 into the limewater, the further change whereby the limewater becomes clear again may be

represented in the equation $CaCO_3 + H_2CO_3 \rightarrow H_2Ca(CO_3)_2$, in which the resulting new substance known as *acid calcium carbonate* is soluble in water.

Whether these chemical changes occur as a series of steps in the order indicated, or are more or less coincident, is of far less importance than it is to have set forth in the equations that which is known to be true concerning what substances *as factors* enter into the chemical change, and what substances result *as products*.

3. Learn definitions for *acid*, *base*, and *salt* as used in Chemistry. Show very definitely how the substances whose formulæ are $CaCO_3$, CaO_2H_2, and H_2CO_3, respectively, meet these conditions. It will be noted that in the formula for the acid calcium carbonate there appears not only the metallic atom Ca from the base, and the radical CO_3 from the acid, but some H from the acid appears also in the formula of the salt. This formula $H_2Ca(CO_3)_2$ is a good illustration of the class of so-called acid salts. It must be remembered, however, that it is upon the presence of the hydrogen atoms in the molecule of the acid salt, and not upon the effect shown by litmus paper, that the classification of salts as *normal* and *acid* depends. In the case of the salt known as acid sodium carbonate ($HNaCO_3$) the solution as shown by use of litmus paper is strongly alkaline.

4. Note the appearance and taste of both sodium carbonate (Na_2CO_3) and acid sodium carbonate. The latter is "baking soda," and the former is known as "sal-soda," and as "washing soda." Test the gas given off as a little hydrochloric acid is added to portions of each of these salts in test tubes. (Hold down in the tube above the

effervescing liquid a glass rod having a drop of clear lime-water on its lower end. This is the usual test for carbonates.)

Repeat the test, using in turn a small lump of marble, and then one of limestone. Try bits of egg shell, and of any other shells at hand. Test any fragments of rock provided, and pieces of old mortar. Be sure to note about what portions (if any) of the marble and of the limestone fail to dissolve in the acid. Account for any such failure.

X. THE HOME SURROUNDINGS

A GARDEN IN THE HOME LIFE OF A FAMILY

1. Aside from the money value of its produce, what are excellent reasons for having a small but well-kept garden connected with every home? Name some of the common amusements for a boy in town. Wherein is an active interest in the home garden, and the employment in it of one's spare moments, superior to any of them? What part may the mother and daughters of a family have in the care of a garden?



FIG. 45. — Counting the profits from the garden.

2. Explain how it is that in the care of the home garden a boy may learn (*a*) to know the conditions for plant growth; (*b*) to understand economic values in home life; (*c*) to assume responsibilities and to discharge duties.

3. Trace a relation (*a*) between lack of home occupations on the one hand, and vicious and evil ways on the other; (*b*) between industry and capable management in the small affairs of life at home during childhood, and the likelihood of becoming worthy and successful men and women.

4. In order to plan, plant, tend, and carry through to success a season's gardening, (*a*) what characteristics must be possessed (or developed) other than strength of muscle; (*b*) what lessons not of books are likely to be learned? How may "*initiative*" (ĭn-ĭsh'ĭ-ā-tĭv) be developed in the care of a garden?

5. Why is it better to have the care of a garden at home than to depend upon a school garden? On the other hand, what excellent purposes are served by a school garden? What application here has the saying, "What is worth doing at all is worth doing well"?

THE CARE OF A GARDEN

1. In planting small seeds like beet, onion, lettuce, radish, turnip, carrot, parsnip, (*a*) about how far apart should the rows be placed; (*b*) about how far apart should the plants be allowed to grow; (*c*) about how close should the seeds be sown; (*d*) about how deep should the seeds be covered? How deep should the soil have been overturned and made loose for these seeds? Why should the surface layer be raked much more than is necessary to make it smooth?

2. About how far apart should the rows be, and how far apart the plants in a row, for (*a*) corn, potatoes, beans; (*b*) cabbage, tomato, and sweet potato plants as trans-

planted? What is the advantage of transplanting over putting the seeds in place? What special preparation of the ground is made for sweet potato plants? What is the manner of planting the common potato? Why is there less



FIG. 46. — At work in the garden.

need of care in the preparation of the soil for corn and potatoes than for onions, radish, and lettuce?

3. Examine closely the various garden seeds provided in the small labeled vials so you may be sure of making no mistakes later when you will be required to recognize at sight and to name any kind given you from unlabeled lots.

What is meant by a *seed?* What are the conditions under which the life dormant within it becomes manifest?

4. For what chief reason other than keeping down weeds ought there to be frequent stirring of the surface layer of soil throughout the growing season? Aside from the untidy appearance they give, what harm is there in allowing weeds to grow? What course, if followed consistently, will destroy the weeds of a garden during the growing season with the least outlay of time and strength? Under what condition of the soil is it more harmful than beneficial (bĕn-ĕ-fĭsh′ăl) to work it? Why is it well to plow (or spade) some gardens late in the fall?

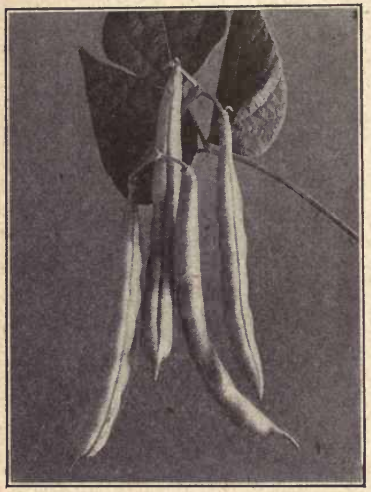


FIG. 47. — String beans. Ready for household use, or for a lesson in botany.

5. About how long after planting may one expect ready for use (*a*) radish; (*b*) green peas; (*c*) string beans? How may a supply of radish and of beans be secured at intervals (or in succession)? What different course may be followed with peas and with corn?

6. On one side of your sheet of paper represent a garden plot 30 feet × 40 feet, using the scale $\frac{1}{4}$ inch = one foot. Represent on it (*a*) by the use of lines of suitable length and at correct distances apart, garden stuff sowed (or set) in rows; (*b*) by the use of circles at correct distances apart that which is planted (or set) in hills.

By the use of figures on these lines, and within these cir-

cles, refer to a numbered list at one side of your sheet that names the kinds of stuff you would raise in your garden.

7. Name both advantages and disadvantages (*a*) from alternating rows of corn and of potatoes; (*b*) from having squash or pumpkin planted in among the corn.

8. Why is it undesirable to have trees, shrubs, or bushes in the garden space? What small fruits may easily be grown out at one side of the garden?

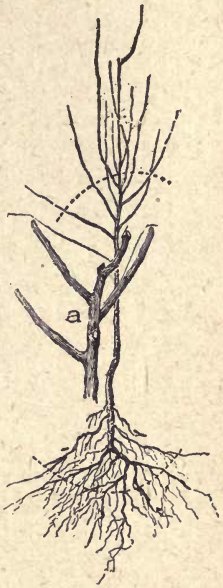


FIG. 48. — Before setting out a young tree, its top and roots should be cut back as indicated by the dotted lines. The top will then have the appearance shown in *a*.

TREE PLANTING

1. Have you ever helped plant a tree? What kind of tree did you plant? Was it for shade, or for fruit bearing?

2. In your locality what are good kinds of trees to plant for shade? Where may these be obtained? About what is their cost per tree? What is a good choice of shade tree for planting as to (*a*) age; (*b*) diameter; (*c*) height? Why not use older and larger trees for transplanting? In what respects is it generally better to purchase trees that have been grown in a local nursery than to get them from a distant part of the country?

3. Why will the growth of a newly set tree necessarily be slow at first? In order that food material for the

growth of plants can be taken in through the *roots*, in what condition must this material be?

4. That the young tree be well nourished from the first after transplanting, (*a*) what form of root is desirable; (*b*) what should be the condition of the soil filled in around the roots; (*c*) why pour water about the roots, and what amount should be used; (*d*) why press the earth firmly about the roots?

5. Why is such great harm done in an exposure of the rootlets to air and sun even for a very short time? While the planting of trees is going on, how may the roots of those awaiting planting be kept from injury? What purpose is served by leaving two or three inches of top soil loose and dry around each tree planted? What is meant by "heeling in" trees for later planting?

6. In what manner may young trees newly set be protected (*a*) from ill effects of heavy winds; (*b*) from animals? Why is it harmful to the young tree (*a*) to break off its branches; (*b*) to pull it about, loosening it in the ground? Why is it harmful to tramp the soil about the tree by running over it?

7. What is the chief use of *leaves* to plants? In transplanting trees why is it generally best to trim off almost all side branches, and to cut back the top? When does a young tree become able to provide for much leaf surface? What is *transpiration* in plants?

8. Where a young tree is to be grown for fruit-raising, what shape of top is desirable? Why so? Why is it better to prune a little every year and not at long intervals? Why

is there need to give more attention to pruning when the trees are young? Why should the branches be cut off close up to the trunk (or main limbs)?

What different manner of trimming is followed when trees are for shade? What is the effect upon the tops of trees when they are set too close?



FIG. 49. — How to prune trees.

9. What are common causes for transplanted trees dying (*a*) when young; (*b*) when grown large? Of what advantage to trees is it to have the ground under them mulched by leaves, or shaded by some growth?

10. Read the poem "Planting of the Apple Tree" by Whittier, and memorize at least one stanza.

TREES OF THE NEIGHBORHOOD[1]

1. The elm is so common a tree that it is well known generally. Its characteristics, too, are well marked. Describe the location briefly but definitely of a large elm growing in your neighborhood. Tell where several others, large or small, are to be found.

2. Name differences in the appearance of the bark (*a*) on older and on younger trees; (*b*) on their twigs and on the trunks.

[1] See footnote of lesson on Temperature Records.

3. Does the main *stem* of the elm usually continue upward through the tree top or subdivide into large limbs? Is the growth of small twigs (the "spray") usually scanty or abundant? What bearing has this on the elm as a shade tree? In general are the outer branches rigid or drooping?



FIG. 50. — A tree in winter.

4. From a study of elm leaves[1] state (*a*) whether the leafstems (*petioles*) below the broad *blades* are long or short; (*b*) what the general shape of the blade is; (*c*) what kind of margin the leaf has; (*d*) what difference there is in the feeling of the upper and the lower surfaces; (*e*) what is a noticeable characteristic of the two sides of the blade; (*f*) just how the leaves are arranged along the stem.

5. After an examination of the *buds* on some of the small branches of the elm tree, state (*a*) their relative locations on the stems, and their location with reference to the places of leaves (or leaf scars); (*b*) their general form; (*c*) what their outer covering is, and what is found within the bud.

6. Pick out elm seeds from a mixed lot of seeds of trees, and examine them closely. Make a drawing of a cluster of elm seeds.

Learn the appearance of the *flowers* of the elm tree (from pictures if necessary). State their location on the stems with reference to the leaves. Be on the lookout in the springtime

[1] Use good cuts in books if necessary.

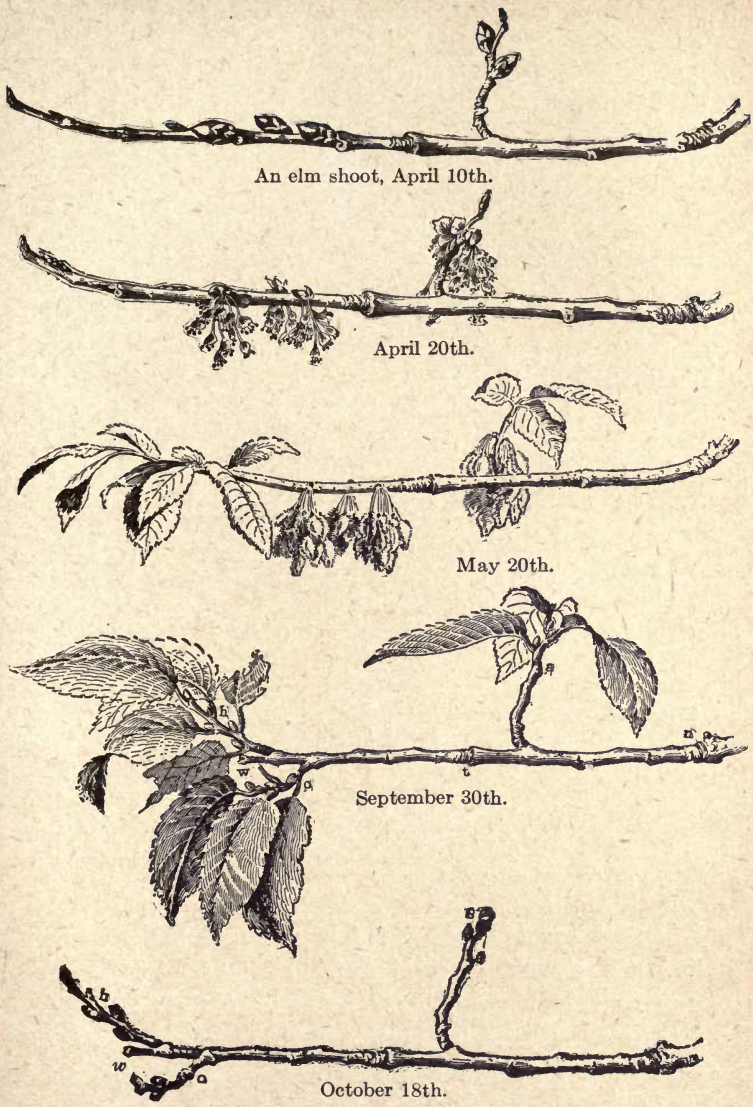


FIG. 51. — Elm twigs, buds, flowers, and leaves.

to recognize elm flowers, and be sure to verify what is shown in the pictures.

7. To what uses is elm wood put other than for fuel? What is its relative value for lumber? Discuss how the cutting of the forests of the United States has contributed to the high cost of living.

8. Arrange alphabetically in a column a list of five or more shade trees known by you. In like manner in other columns, write (*a*) the names of five fruit trees; (*b*) the names of five trees of which you have read or heard, but which otherwise are unknown to you.

9. After such instruction as may be needed in the use of the "Key" in Farmers' Bulletin No. 468, make use of your copy as you come and go outside school to verify your list of shade trees, employing it with different trees of the same kind till you are perfectly familiar with the distinctions it makes.

State what you have noted of different trees of the same kind as to form and general appearance even when age and conditions of growth are much the same. *Note, too, that there are varieties of the same kind of tree, e.g.,* there are several different kinds of elm with marked characteristics that invariably distinguish them.

10. In a tabulated form suitably arranged under appropriate headings, write in lines opposite each of the five shade trees named in paragraph 8 the characteristics of each kind of tree. (Write lengthwise of the page, and so that *the same items* for all trees fall in the same column.) This makes it possible, by following down a column, to note the

differences among these trees in any one respect. In an elementary way this grouping of facts is a "Key" for the identification of these trees.

11. Outside of school hours make a sketch of some one of the shade trees you named, showing its form and manner of branching. State (by map or otherwise) just where this tree is to be found. Hand in the sketch.

Using the Key of Farmers' Bulletin 468, and any available reference books on trees, determine the name and variety of a large number of trees in the immediate vicinity — trees which before were unknown to you. Cultivate the acquaintance of these trees till you are sure of recognizing them at sight, and have an interest in their growth and well-being as friends of yours.

Be prepared to state in writing (as an examination for school credit it may be) the name and variety of any designated tree or trees of the neighborhood, together with the characteristics upon which you base your decision. (Be sure to include in your studies some of the evergreens and ornamental trees of the vicinity.)

SOME PLANT STUDIES

1. Note the general form of the roots of some corn plants unearthed from flower jars in which they have been growing in the room.[1] Flatten one of the best of these specimens against white cardboard, and make a drawing to represent its appearance. The roots of the grasses and of the grains are very generally of this *fibrous type*. Gardeners, florists, and nurserymen in many instances transplant trees, shrubs, and other plants for the express purpose of causing them to form a large mass of fibrous roots.

[1] Provision for these studies must be made ahead of the time set for this lesson.

2. Select a good specimen of long scarlet radish (likewise grown in the room), and make a drawing of it as an illustration of a *taproot*. The root of the dandelion is of this form, and trees that have never been transplanted may have one or several such main roots. Plants with taproots are likely to become strongly embedded.



FIG. 52. — Taproot of the dandelion.

3. What is the general purpose (*a*) of the roots of plants; (*b*) of their stems; (*c*) of their leaves? What may be considered the primary purpose of flowers and seeds?

4. Examine some stems (stalks) of corn and of the grains, and compare their structure with that of some young growths of trees or shrubs. Examine some vigorous shoots of last season's growth of various trees (*a*) for arrangement of leaves (or leaf scars) on the stem, noting whether it is *alternate, opposite,* or *whorled;* (*b*) for places of the buds with reference to these leaves. Some stems are climbers, as the hop plant, morning glory, etc.; others are creepers, as the strawberry. The common

potato is an underground stem known as a *tuber*, and its "eyes" are buds from which new potato plants will grow as "sprouts."

5. Out of a supply of leaves brought into the room by the teacher select specimens to illustrate *parallel-veined*, *feather-veined*, and *palmately-veined* leaves.[1] Make drawings of each kind.

6. Make drawings of leaves that are (*a*) *simple;* (*b*) *palmately compound* and *pinnately compound.* (Pinnate = feather-like.)

7. Make drawings to show leaves whose margins are *entire*, *toothed*, and *lobed*, choosing under direction of the teacher the best specimens at hand.

8. Write in a column a list of four kinds of leaves represented in the supply of fresh leaves at hand (or of mounted specimens). At the right of each such leaf-name write a single descriptive word under each of the following headings, so arranging these descriptive terms that they fall into columns thus: —

	Name of Leaf	Veining	Margins	Kind (if Compound)	Arrangement on Stem	Kind of Surfaces
1	—	—	—	—	—	—
2	—	—	—	—	—	—
3	—	—	—	—	—	—
4	—	—	—	—	—	—

[1] See illustrations in Botany texts, and other books.



FIG. 53. — Type forms of leaves.

BIRDS ABOUT OUR HOMES[1]

1. Make a list of ten *birds* that are so well known to you that you recognize them and can name them at sight.

2. Name the several particulars in which these birds of your list are alike — those features of build, covering, activities, and manner of life that are common to all. In what respects do they all differ from domestic fowls such as the hen?

3. Tell what there is characteristic of any four of the birds named whereby you identify them. (Include details of their nesting, rearing of young, migrations, relations to men and to other birds, their songs, and the differences in plumage of male and female.)

4. Make another list of birds known to be more or less common in your neighborhood but not recognized by you at sight with certainty. Underscore the names of any in this list that you think you might be able to call by name if you should see them.

5. Select one bird from your first list and write a brief description of it, setting forth its characteristics in a way that would materially assist another person in recognizing the bird.

6. Make another list of birds whose names are familiar but which you would not recognize at sight. Group these names into (*a*) those of the region where you live; (*b*) those of foreign parts.

Two weeks before the close of this work in General Science hand in a list of the birds that you have learned to know between now and then, telling when and where you have seen them, and upon what they seemed to feed.

[1] See footnote of lesson on Temperature Records.

XI. LOCAL INDUSTRIES

SOME OCCUPATIONS OF THE COMMUNITY

1. Name a carpenter whom you know. Tell something of the work he does. Of whom does he get lumber for his work? Name several people in town who are (*a*) carpenters; (*b*) lumber dealers. Why are there fewer lumber dealers than carpenters? How much does a carpenter get for a day's work? How does a lumber dealer get paid for his time and labor? What sooner or later is the business result when a lumber dealer cannot sell his lumber, or sells it for less than cost? Name some differences between making a living by working at a *trade* and by engaging in business. At what time of year is a carpenter likely to be out of work? What expenses may a lumber dealer have when there is no business for him?

2. Whence comes the lumber that the dealer sells? How is it brought to him? From what is lumber made? Why do we not get lumber nearer home just as we get hay and corn? What will be done when the supply of lumber from the sources named is exhausted? What difference in the cost of lumber will this cause? Give several illustrations of other material that is already substituted for wood. In what other ways is the timber supply of the country being conserved to some extent? What are the special duties of the Forest Service of the United States?

3. Who in your community are railroad men, *i.e.*, in the employ of the railways? Name others who are employed in conveying freight, express, and people to and from the station. What would be true of the business of these men if there were no railroad into town? What besides lumber is shipped as freight into your town by railroad?



FIG. 54. — An artificial waterway.

What other means for freight transportation have some towns? Name a place having transportation facilities not possessed by your town. How is the size of towns affected by having ample facilities for transportation? Why is this so?

4. What other supplies are commonly handled by the lumber dealer? Where does he get them? How are they

brought to him? Why are they brought so far, and at such cost? Who determines what the freight charges shall be? What is involved in the determination of what is a fair and reasonable charge? Why does not every man bring in his own supplies? Why are not competing lines of transportation established to lessen freight rates? How is it that inland waterways regulate freight rates?

5. Name other lines of business that furnish the carpenter supplies (*a*) for building purposes; (*b*) to live upon. Name several men you know engaged (*a*) in trade (business); (*b*) in agriculture. In this latter case name some of the various kinds of farm work carried on by them. Why does one farmer raise corn and alfalfa and hogs, and another keep cows for butter-making?

6. Under the heading "Agriculture" make a list of the occupations in which men engage that have to do directly with farming, such as stock-raising, fruit-raising, dairying, gardening, general farming, etc. Underscore those that are followed in the community round about you.

7. Make a list of the industries other than trades and agricultural pursuits represented in your community.

8. Make a list of the various trades, such as blacksmith, mason, etc.

9. Name the professions represented in your town, — lawyer, physician, etc.

10. List other occupations of men, — dentist, grocer, milkman, printer, etc., grouping them under one or the other of the headings "Producers," or "Consumers." State wherein some who are classed as consumers are to an extent producers, and those classed as producers also are consumers.

11. Name several occupations in which women are engaged outside the home in earning a livelihood. In what respects does successful management of household affairs demand higher intelligence of a woman than shop or office work? In what respects must the housewife exercise a high degree of business ability in expending that part of the family income used to meet the cost of living?

12. Give arguments against child labor in community life. Why is it desirable to have some employment, either indoors or out, for children at home? Name some home duties for which children may assume responsibility? Wherein may there be educational value in such duties?

MODERN INDUSTRIAL LIFE

1. Explain the fact that the shoemaking industry, for example, is centered in a relatively few localities, with a daily output of thousands of pairs of shoes for a single factory, rather than in small establishments scattered all over the country. Where must the people live who are engaged in any such industry? What is the effect of these conditions upon the distribution of population in the country as a whole?

2. Compare the advantages enjoyed by people who move to centers of industrial life with those commonly experienced in the more sparsely settled rural communities. Name some of the disadvantages to a wage-earning people incident to life in excessively congested quarters. What are some of the reasons that lead to the crowding together of different industries in a small district of a city instead of choosing locations more widely scattered?

3. What relation is likely to exist between any chances of advancement in position for a wage earner, and his educational and industrial preparation for his work? What conditions may overrule this natural association? Name



FIG. 55. — When work hours are over.

some factors, wholly apart from the *efficiency* of the individual worker, that enter into the computation determining the pay that can be given employees in an industrial concern.

4. How large a part has any one person in the making of a shoe, or the making of an engine? Of what character is the work of a shop or factory operative generally? What is the effect upon a person mentally and physically who is engaged day after day as an attendant upon a machine? What different results may follow the use of machines by

skilled mechanics, professional men, builders, engineers, and others *to facilitate the execution of any undertaking?*

5. Why should years of regular attendance at school contribute much towards keeping persons who operate machines masters of their labors rather than slaves to the

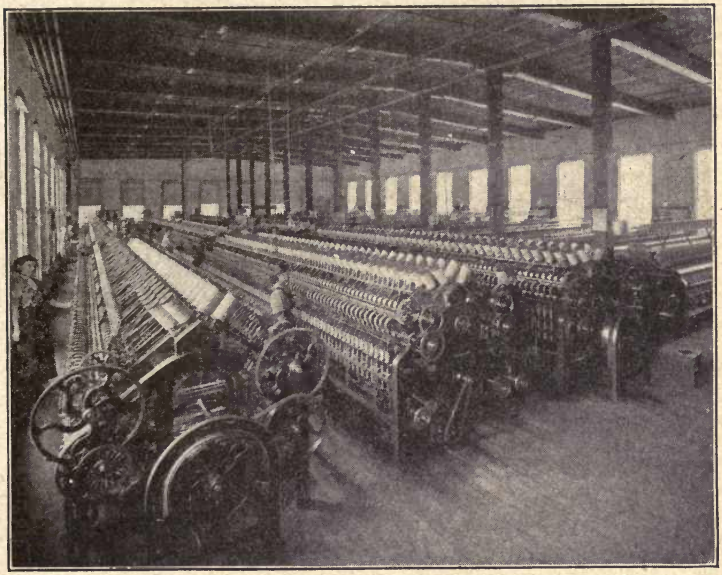


FIG. 56. — One person can supervise many machines in the spinning room of a cotton factory.

machine? How is it that much attendance at schools may sometimes fail to make a person an efficient worker in life's affairs? In addition to the information one may have acquired, what is characteristic of a person who is really "educated"?

SANITARY CONDITIONS FOR THE WAGE EARNER

1. From personal knowledge, or as you have heard the facts told, write an account of the hardships that have befallen some family by reason of accident, illness, or other disability directly traceable to conditions of employment or to the culpable negligence either of the individual or of his employer. Observe in a general way the following conditions for the narrative: —

(*a*) Confine yourself quite closely to known facts, and discriminate between what is more important and what is incidental. Avoid setting forth *as facts* things only surmised to have been true, or that are merely the opinions of yourself and of others concerning the case.

(*b*) Indicate obvious measures to be taken by the employer and by the employee for the prevention of further cases of the kind.

(*c*) The name of the person of whose case you write is unnecessary. Speak of Mr. A if you desire. Have in mind the hardships and losses not only of the individual but of the family and community as well.

2. In the list of employments given below, injury to the workers is likely to occur unless special precautions are taken to remove dust-laden air. Copy the list, and to it add three other industries in which dust is a menace to the health of the workers.

tool grinding	cotton spinning	flour making
sand blasting	wool finishing	foundry work

3. In what ways is danger to health from dust in factories and shops lessened or entirely eliminated? How is it that long-continued breathing of dust-laden air, otherwise pure

and free from germs, leads finally to tuberculosis? What is the relation between warfare upon tuberculosis, and the prohibition of spitting on sidewalks and on floors of mills and factories? In what sense does the statement that "society has the right to protect itself" apply here? In matters of contagious diseases what is done to protect people generally? What may very properly be done with those who at school and elsewhere wilfully and persistently refuse to regard the rights and welfare of others in matters of health and decency?

4. In what very true sense is the school a workshop? A good schooling should give what advantages to anyone when seeking employment at any time? What besides good health and physical endurance is desired of those who in office, shop, and factory are put in charge of complicated and expensive machines, and are called upon to use time and material to the very best advantage? Aside from skill in workmanship, what is meant by "an intelligent workman" in any of the callings of life? What is it for an employee to "take the initiative"?

5. One of the purposes of attending school is to become more capable and more efficient in the affairs of life than would otherwise be possible. State some things in common between the study of science in school (with its requirements to master and use what may be learned from books, experiments, and the experiences of life), and the procedure followed by (*a*) the lawyer who undertakes any case at law; (*b*) the contractor who seeks to accomplish any large job; (*c*) the housewife who desires to spend the family income most advantageously.

XII. THE FARM, AND OUR FOOD SUPPLIES

THE HEN[1]

1. Tell what kind of fowls you keep at home (if any), and their distinguishing characteristics in color, build, etc. How could you identify any hens of yours in case they were to get with a neighbor's fowls?

2. In what ways are chickens hatched? What care must be given little chickens? What feed is used for them? What other provision must be made for them? What food do fowls get for themselves when running at large?

3. Do hens chew their food as we chew ours? How is their food ground, and where? Why is there no need for horses to eat gravel and bits of stone? Does a hen have a tongue?

4. What reason is there to believe that hens can hear? Where in the head are a hen's ears located? Where are the nostrils? How does a hen drink?

5. Do hens shut their eyes? What difference in their eyelids from ours? (Watch for a third lid that moves sidewise over the eyeball.)

6. Why do not hens fly as freely as do birds? Where are the wings attached to their bodies? Where in the body are the muscles for flying?

[1] It may be possible to have in the room for a few days one or more fowls in a coop such as used at poultry shows.

7. Of what use to the hen are feathers? Of what value are feathers for household uses? How do hens keep clean? What provision is made for new plumage?

8. In what respects is the foot of the hen different from (*a*) the foot of a horse; (*b*) a man's foot? How many toes on a hen's foot? To what uses do hens put their claws? The part of a hen's leg above the toes (the part that is covered with scales) corresponds to what part of the human body? Why do not fowls fall off when asleep on perches?

9. What is the purpose of (*a*) the comb; (*b*) the wattles? What significance in their changes in color?

10. Explain differences in color in chicken meat.

EGGS

1. Remove the shell from an egg that has been boiled in some "Easter dye" solution. What is the significance of

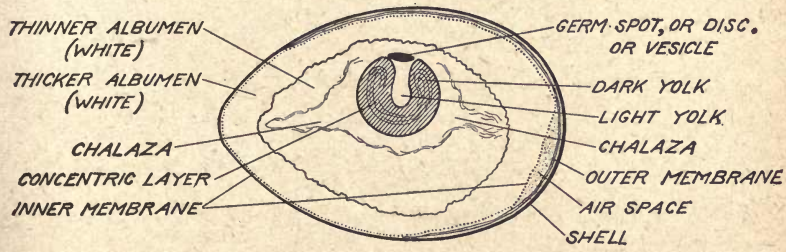


FIG. 57. — The parts of an egg.

any coloration through the shell? Recall why canned goods do not spoil. What can be done to the shells to keep eggs for a long time? What conditions favor the decay of all animal matter, including eggs?

2. Carefully break a fresh egg into a clean sauce dish, and note (*a*) the germ, and its location; (*b*) the light and dark parts of the yolk; (*c*) the *chalaza* (kȧ-lā′zȧ).

Examine the large end of the broken shell for the air space, noting the membranes inclosing it. Infer if air can pass through these membranes.

3. To a bit of the shell in a test tube add some strong acid, and describe the action. Note the effect of any escaping gas upon a drop of limewater.

4. To a small piece of boiled white of egg in a dish add strong nitric acid; note any color change as the acid is warmed a little.

Pour off the acid, rinse with water, and then add strong ammonia water. Describe any further color change.

These steps and their results illustrate tests for the important class of food substances known as *protein* (prō′tē-ĭn). The albumen of egg is but one of these. They are the tissue-building material of our foods.

5. Observe closely, and state the results, as the teacher adds alcohol slowly to a little uncooked white of egg in a test tube, shaking the tube from time to time.

POULTRY KEEPING

1. Aside from profit what are good reasons for keeping a few fowls at one's home? Name some classes of people other than farmers who can profitably engage in the poultry business on a small scale? What traits of character are quite essential in one who is to make a success of poultry raising? What is a safe course for any one beginning to keep poultry?

2. Give arguments for and against making poultry raising a sole business. What are the advantages of making it incidental to general farming?

3. What are the advantages and disadvantages in keeping pure-bred stock?

4. What is the importance of keeping the poultry accounts in a businesslike way?

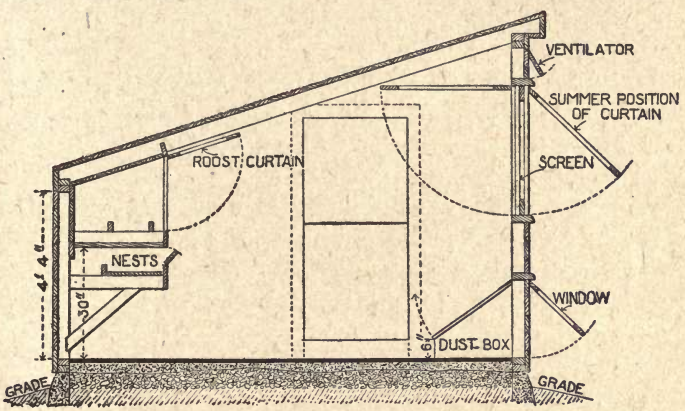


FIG. 58. — Cross section of a poultry house.

5. What may be considered a good site for a chicken house with reference to (*a*) character of the ground; (*b*) nearness to the barn and stables? What preferably is (*a*) the kind of foundation for the house; (*b*) the nature of the floor, and the care to be given it? What covering should be provided for the floor when it is of cement?

6. What provisions should be made (*a*) for keeping the chicken house clean; (*b*) for extermination of lice and mites? What uses have whitewash and coal-tar wash? How is "whitewash" prepared?

7. Discuss arrangements for warmth, for light, and for the ventilation of the chicken house. What provisions should be made for exercise by the fowls, and for dust baths? Where should nests be placed, and what schemes may be employed to keep them clean?

8. Make a diagram in some detail showing the interior of a chicken house. At about what cost may a substantial house for a flock of twenty fowls be built?

9. In the hatching of chickens, what advantages (*a*) in setting hens; (*b*) from use of *incubators?* Describe in a general way the construction of an incubator.

10. Where incubators are used, (*a*) what time is required for hatching the eggs; (*b*) what per cent of the eggs are likely to hatch under favorable conditions; (*c*) what care should be observed as to the temperature maintained, the supply of moisture for the eggs, and their turning and cooling?

11. How is the fertility of eggs to be determined after they have been a few days in the incubator? How soon can this be done?

12. What arrangement serves as a chick nursery within the incubator? Of brooders, state (*a*) their purpose; (*b*) the manner of their construction; (*c*) the rate of reduction of temperature in them; (*d*) their period of use.

13. How often should little chicks be fed, and how much at a time?

14. In general, what care should be given grown fowls? State the kind, and the relative cost of foodstuffs for hens.

How can green feed be provided (*a*) in winter; (*b*) as pasturage in summer? How may exercise for the fowls be secured through a feeding scheme? What provision may be made for "picking material"? What provision must be made for drinking vessels, and for a water supply?

15. In the marketing of poultry and eggs (*a*) what advantage is there in direct sales to the consumer; (*b*) what care should be exercised in grading the quality of the product sold?

16. Name some diseases to which fowls are subject. What preventive measures should be employed?

17. State the educational values possible for boys and girls (*a*) from school courses in poultry keeping; (*b*) from the care of poultry at home. What relation may this school instruction in poultry keeping have (*a*) to community life; (*b*) to exhibits at the schoolhouse, and at Fairs?

THE HORSE

1. Do you have a horse at home? If so, why do you keep it? (If not, why not?)

2. If a horse should get out of the barn some night and go away, how could the owner know it as his horse when it was found? In what other ways might it be identified?

3. Why is it best to keep away from strange horses? How does your horse behave toward you? Why so? In driving, how do horses sometimes misbehave? What makes them do this? Why do horses so seldom misbehave?

4. Who else that you know keeps a horse? For what use? What kind of horse best serves (*a*) the man who delivers heavy loads of coal; (*b*) the livery man whose

horses must go many miles a day? Wherein do ponies differ from horses?

5. What do you feed your horse? How often do you feed it, and how much at a time? What changes of feed are sometimes made (*a*) winter and summer; (*b*) when the horse is working hard and when doing nothing? What are the present market prices (*a*) of hay; (*b*) of oats? What other care should be given a horse besides feeding and watering it? Why is this needful? What is true of the amount of feed a horse needs if kept in a warm rather than a cold stable in winter? What care should be given a horse if hitched outside on a very cold day in winter? Why should a horse not be driven fast on cold days?

6. When you drive your horse, how does it know where to go? Why do you not need to have bits in your mouth that you may go where you ought? How does a horse know when to stop? To what part of the harness are the lines fastened? Why should a driver not jerk hard on the lines? In cold weather, how may the bits cause pain to the horse?

7. What is the checkrein of a harness? Hold your head for a little time as the horse has to hold its head when checked up high. What is the feeling you have?

8. Of what use in the harness are (*a*) tugs; (*b*) holdbacks? Against which part of the body does the harness rub most when the horse is drawing a heavy load? What care is necessary because of this?

9. How does a horse show (*a*) that he is impatient; (*b*) that he is tired; (*c*) that he cares for you; (*d*) that he is afraid of you; (*e*) that he is afraid of something by the way? When only should a whipping be given a horse?

10. Describe as well as you can the shape of the horse's head as compared with your own. Make on your paper a drawing of a horse's head.

11. Where in its head are the eyes? Of what advantage to the horse is this location?

12. Where are the ears placed? What are some advantages from this position?

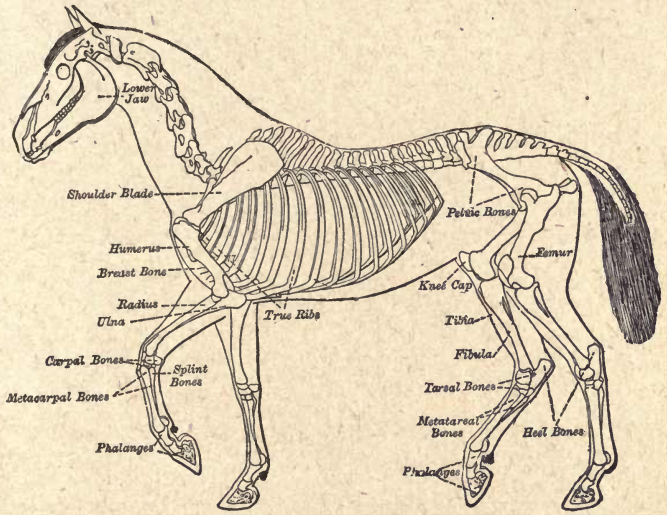


FIG. 59. — Skeleton of a horse. Note especially the arrangement of the bones in foreleg and hind leg.

13. Watch the horse eat, and see how it gets food into its mouth. Why do we not need to eat in the same manner?

14. Watch a horse drink, and then a hen. What about a hen's mouth is different from the mouth of a horse or of a man?

15. What is peculiar about a horse's foot, and by what name is it called? Why do we have iron shoes on the feet of a horse (*a*) in winter; (*b*) in summer? What harm results from keeping the same shoes on too long? To what part of our foot does the horse's hoof correspond?

16. Show in a sketch of the hind leg of the horse where the joints[1] are that correspond (*a*) to our ankle; (*b*) to our knee; (*c*) to our hip.

17. On what parts of the body of the horse is the hair of unusual length, and what are the names given these different long growths? Of what use to the horse is the tail? What care should be given the hair and skin of the horse? What changes have you noted in the hair of the horse at different seasons?

COWS AND THE DAIRY INDUSTRY

1. Name several considerations that enter into the market value of a cow for dairy use. About what is the present value in your community (*a*) of common "grade" cows; (*b*) of "full-blooded" stock?

2. How in general does care of the cow compare with that of the horse in matters of food, drink, shelter, and kind treatment?

3. In what respects is the foot of the cow unlike that of the horse? What is a noticeable difference in their tails?

[1] Notice horses from time to time till you can locate the place of each such joint. Note the places of the corresponding joints in the foreleg.

4. Where are the horns with reference to the ears? Of what use are the horns? Why is dehorning of cows so general in dairies?

5. How many teeth has a cow in each jaw? What takes the place of the front teeth in the upper jaw? Does

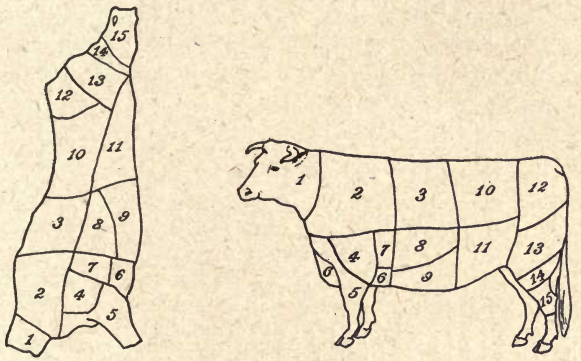


FIG. 60. — Cuts of meat in a beef animal.

1. Neck
2. Chuck
3. Ribs
4. Shoulder
5. Fore shank
6. Brisket
7. Cross ribs
8. Plate
9. Navel
10. Loin
11. Flank
12. Rump
13. Round
14. 2d cut round
15. Hind shank

the cow in grazing bite off grass as does the horse? What is peculiar about a cow's way of eating hay and grass, and what is meant by a cow's "chewing the cud"?

6. Describe the manner in which a cow lies down and gets up, comparing it with the way of a horse.

7. Make a list of the various cuts of beef bought at the butcher shop, with the name of the part of the animal whence each is obtained.

8. State briefly the processes of changing the hides of cows into leather. Explain why leather does not decay.

9. What are various uses for (*a*) cow's hair; (*b*) the horns; (*c*) the blood; (*d*) the bones; (*e*) the fat?

10. Name at least two different breeds of cows, and state in what respects they differ in (*a*) size; (*b*) color; (*c*) quantity and quality of milk given; (*d*) beef production.

11. Where a cow is kept for profitable milk production, what must be true (*a*) of the quantity and quality of feed; (*b*) of the water supply; (*c*) of regularity in feeding and milking; (*d*) of definite knowledge of the income and outlay for each animal?

12. Of what advantage is the use of the cream *separator* in dairying as to (*a*) amount of cream taken from the milk; (*b*) labor involved in the care of milk? In what ways has the general use of cream separators largely changed the industry of butter-making? What use does the farmer make of the milk from which the *butter-fat* has been separated?

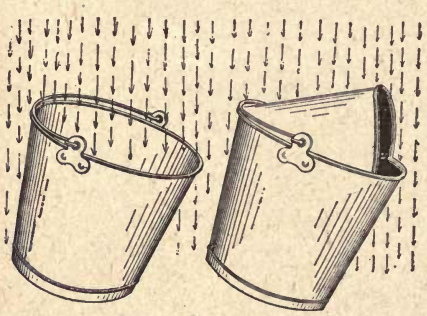


FIG. 61. — Clean milk requires precautions at milking time.

13. What sections of country are especially favorable for dairying as regards (*a*) general character of the country for tillage; (*b*) price of land per acre; (*c*) distribution of rainfall throughout the grazing season; (*d*) nearness to town and city as markets?

14. Even where milk is sold in stoppered bottles, how may the consumer be endangered by carelessness and ignorance

(*a*) in the care of the bottles; (*b*) at milking time; (*c*) in the stabling of the cows?

15. Where only the butter-fat of milk is sold, what animals may be raised to add to the profits of the dairy business? Why should there be a greater and ever increasing fertility for the dairy farm in contrast with the very common impoverishment of farms cropped year after year with corn, small grains, cotton, etc.?

SOME FOODSTUFFS

1. Melt (or soften) a little butter, and put a drop of it on a piece of glazed paper (letter paper). What appearance is given the paper? What class of substances gives similar results? What is the nature of butter? Describe the steps in butter-making. Of what use is butter as a foodstuff? What are good reasons for its use with bread?

2. What is *oleomargarine?* What are the claims for and against its use as a foodstuff? Why is there a heavy government tax upon oleomargarine? What is "cottolene" and what are its uses? Name other like compounds having a similar use.

3. What conditions of temperature and of acidity are favorable for the best results in churning? What is (*a*) buttermilk; (*b*) lactone? What is renovated butter, and why is it less in price?

4. Observe very closely the results as the teacher performs the following experiments, and tell in each case what is the distinction shown between real butter and its imitations: —

(*a*) In a spoon heat in turn small pieces of each substance, stirring them with a match stick as they boil. Note which boils with much foam and which with much sputtering.

(*b*) Note the differences in results as the substances are tested separately as follows: Put a small lump into a test tube one fourth full of milk, and heat till the lump is melted; then stir the liquid with a long splinter of wood, cooling the tube under the faucet till the fat hardens. In one case the fat should collect in a mass that can be removed on the splint, and in the other cases it remains scattered in granules throughout the milk.

Summarize the results by which any one of these substances may be identified with a reasonable degree of certainty.

5. What per cent of butter-fat should be present in milk? What per cent of milk is water? What preservatives have been most commonly used in milk? Wherein is the harm? What causes the souring of milk by natural processes? How is this ordinarily delayed in household uses?

6. What is (*a*) condensed milk, and its especial worth; (*b*) sterilized milk; (*c*) Pasteurized milk?

7. Observe results closely, and state what is noted as the teacher (*a*) adds to one fourth test tube of milk a little vinegar, warming and shaking till separation of *curd* and *whey* occurs; (*b*) tests some of the curd with nitric acid, and then with ammonia solution, for protein food material.

8. Describe briefly the making of cheese. Mention various kinds of cheese, and the differences in their manufacture.

9. Name three food constituents of milk. By what means may each be separated from the others? Discuss milk as a perfect food for infants.

10. Distinguish between (*a*) suet, tallow, and lard; (*b*) veal, mutton, and pork. What are the chief reasons for cooking meat?

11. What different means are employed to prevent decay in uncooked meats? In sausage made up in quantity and exposed for sale, (*a*) what preservative is sometimes used; (*b*) what is used as a "filler"?

12. What great advantages affecting our food supply have resulted from the canning of meats and fish? Why are there so many cases of *ptomaine poisoning* from chicken or salmon salad? When a can of meat is opened, what precautions should be taken before the meat is eaten? What is the nature of ptomaine poisoning?

13. What are the chief food constituents of lean meat (muscular tissue)? What are their digestive solvents? What are *peptones?* What is the nature of the digestion of fats?

14. What is the chemical nature of bone? Which are the chief foodstuffs providing bone-building material? How may the relative weight proportions of animal and mineral material in bones be quite readily determined? What use is made by the body of the "lime" in water?

15. From what is *soap* made, and how? Give the nature of *glycerine,* and its uses.

LESSONS ON CORN

(a) *Corn in the Field*[1]

1. Measure the distance between hills of corn in a row, and then calculate the number of them in a row 16 rods long. Measure the distance from row to row, and calculate the number of rows in a width of 10 rods. Calculate the number of hills in an acre (160 square rods). With four kernels per hill, how many kernels are needed to plant an acre?

2. Count the number of stalks in a plot nine hills each way. With three stalks[2] to the hill, how many stalks should there be in the plot? What is the per cent of shortage (or excess)?

3. Count the number of ears in the plot of 81 hills. With one ear on each of three stalks[2] per hill, how many ears should there have been? What per cent of shortage (or excess) is found? How many ears shortage (or excess) is this per acre? How many bushels of ears in this, taking 100 ears per bushel as an average? How much shelled corn? What value has this amount of corn at the market price?

4. About what is the average height of the stalks? If any are broken down, at what places with reference to the joints (*nodes*) are the breaks? Where are the leaves attached to the stalks? What is the purpose of joints in the framework of our bodies? What is told of the corn plant by the varying lengths between joints?

[1] In the autumn.

[2] Use four per hill for those varieties having relatively short stalks and small ears.

5. Cut a stalk crosswise, and notice where the woody fibers are closest together. Slit a stalk lengthwise, and compare the structure at the nodes and between them (*internodes*). What is true of the relative size and strength of a stalk at the joints and between them? What connection is there between the woody fibers of the stalk and the fibers (*veins*) in the leaves? How are the fibers arranged in the stalk relative to one another? How is it in the leaves? What diameter (and circumference) has a stalk of average size two feet above the ground?



FIG. 62. — Structure of cornstalk.

6. About how high on the stalks are the ears? What is the length of the ear stem? What would be one disadvantage in having (*a*) the ears too high up; (*b*) the ear stems too long? Where are the ears with reference to the leaves? What change is there in the shape of the stalk where the ear is? How are the leaves arranged on the stalk? When do corn leaves curl? What is the cause of this curling? What is the advantage to the plant in this?

7. Gather one of the largest and one of the smallest of the ears. What is true of the size of the stalk on which each grew? What is the number of stalks in each of these hills? What seems a good number of stalks for a hill, and what is the best relative size of stalk?

8. Uproot one or more hills, and describe the general character of the roots. What special use have the "air roots" of the corn? To about what depth did the corn roots grow? What relation has this to the depth to which the soil should have been plowed? How far sidewise did the



FIG. 63. — Roots of the corn plant.

roots reach out? What bearing has this on a late cultivation of the crop?

9. Select a good ear and carefully remove its husks. If the stem bearing the ear were greatly extended outward, to what would these husks on this new stalk correspond? Note to what each of the threadlike silks is attached at its inner end. Observe in other ears whether the silks extend outward beyond the husks. Where on the cornstalk were other blossoms that bore stamens and an abundance of pollen grains? What is true of the times of appearance of silks and "tassels"? How will it affect the crop if the weather at such a time is very hot and dry, or too wet and cold?

(b) *A Study of Ears of Corn*

1. Count the number of rows of kernels on an ear of medium size, and the number of kernels in one row. Calculate the number of kernels per ear. How many ears are needed to plant an acre? (See paragraph 1, Corn in the Field.) How many bushels? (See paragraph 3.) Of the ear that you examine, state (*a*) if the kernels fill the ear entirely over the tip; (*b*) if there are any places where kernels are missing; (*c*) if the base of the ear is large and well filled out. State whether the kernels are crowded close together on the cob, and whether they are of uniform size and shape.

2. Choosing what you consider the best ear, find the circumference at one third its length from the base. Calculate the ratio of this circumference to the length of the ear. Break the ear at about its middle and determine the ratio (*a*) of the diameter of the cob to the diameter of the ear;

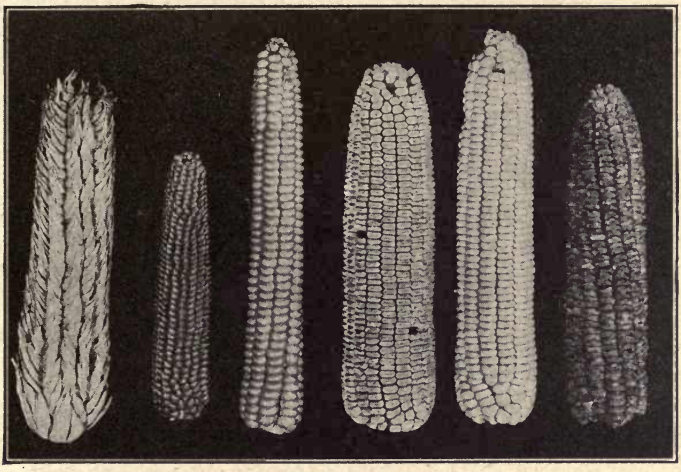


FIG. 64. — Specimen ears of different varieties of corn.

(*b*) of the area of the broken end of the cob to the broken end of the ear.[1]

3. Get a good ear of cured (old) corn and find the ratio of the weight of the cob to the weight of the ear before it was shelled.

4. Somewhat at length, and very specifically, state the characteristics of the best ears of corn.

[1] The areas of circles are to each other as the squares of their diameters.

5. What advantage is there (if any) in having the kernels wedge-shaped? State if there is any dent in the large end of the kernel. What differences are there in the sides of a kernel? With a knife remove the thin outer coating of a kernel (its hull). Note where the color of the kernel seems to be lodged. At what place in the hull is a hole found? What is its probable purpose?

6. Examine some kernels that have been in water for two or three days, and away from the light. What change has occurred in the size of the kernel, and of the groove in its side? Having removed the hulls, cut some of the kernels lengthwise along the groove, and others lengthwise but at right angles to it. Observe the little embryo in each case. The large portion of the kernel surrounding the embryo is the *endosperm.*

7. Put several of the soaked kernels between blotting papers kept moist in a warm room for several days. Examine the embryo, and infer what it is likely to become. Distinguish between its *plumule* and its *radicle* (root). Distinguish any parts of the plumule, and of the root. Observe any hairlike rootlets, and tell where they are. The change which has taken place in the kernels is called *germination.* After corn is planted, to what extent can conditions for germination be controlled? About how early in the Spring is it safe to plant corn in your section of country?

8. Fill a glass fruit jar with mellow soil that is somewhat moist (but not water-soaked). Push down into the soil next the sides of the jar where they can be seen several kernels that have been soaked for three days. Have them at different depths below surface. Keep the soil just moist,

the jar covered with a black cloth, and all conditions for germination favorable. Examine the jar daily till the best depths for planting seem apparent. Note any marked tendency in directions of growth of the plumule and of the rad-

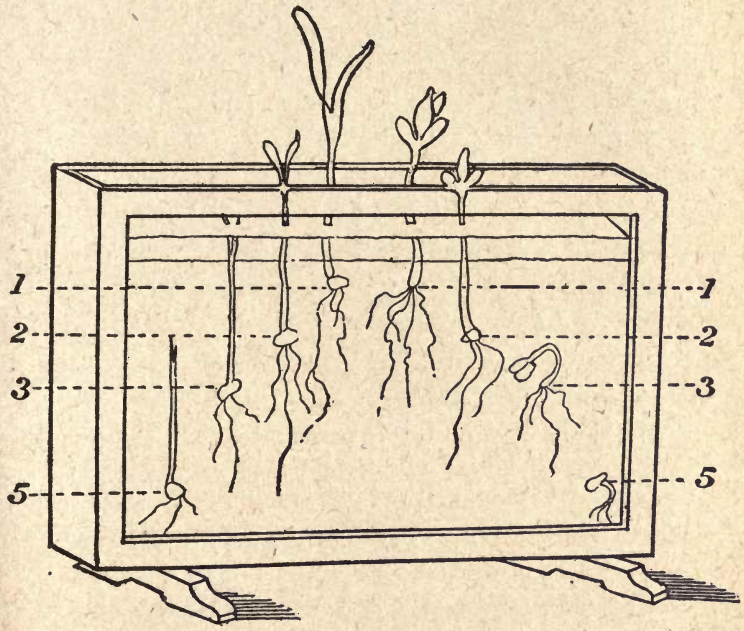


FIG. 65. — Results of planting at different depths (in inches).

icle. What is the number of leaves when the young plant comes through the soil? What condition of the soil favors the outward growth of root and plumule? What preparation of the soil is desirable before planting corn for a crop? What purpose is there in the cultivation of the soil at its surface only during the growing season?

(c) *Corn Raising as an Industry*

1. What variety of corn is most commonly raised in your section of country? Name some other varieties.

2. Tell how seed corn for another season should be selected. How should it be cared for after it has been gathered? How is seed corn tested for its powers of germination?

3. Describe somewhat at length the manner of gathering a crop of corn. What determines the time for beginning its harvest? About how long a time is it from planting till the crop is ripe enough to be gathered? Why is the new crop often stored for a time in cribs?

4. What machinery is employed in raising a corn crop? In harvesting it? In marketing it? In general, is the cost per acre of raising a large yield of corn likely to be much more than for a small yield? Why so? What expense items are likely to be greater? What are several advantages to the farmer in feeding his corn on the farm rather than selling it? As land values and the cost of labor increase, involving need of larger capital to carry on successful farming, what is likely to become more and more true of the degree of business ability necessary to make farming a paying industry?

5. Name a large number of the products of packing houses where corn-fed cattle and hogs are marketed. How very largely is this livestock brought to the packing houses? How are the packing house products distributed to consumers? What would be the effect upon the number of men employed in these fields of industry if there should be a failure in the corn crop for a year or two? What would

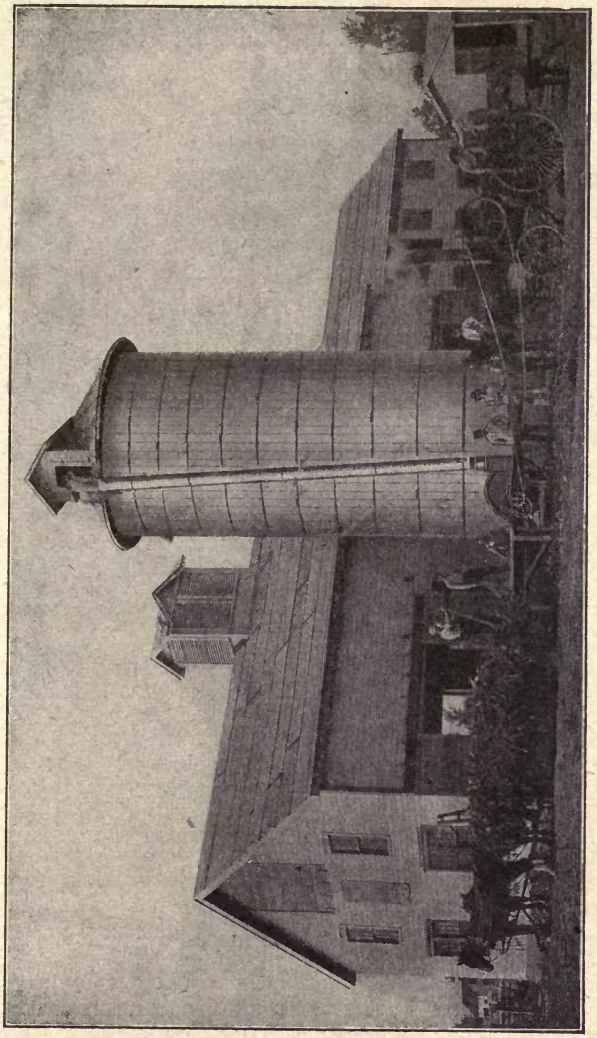


FIG. 66. — Filling the silo.

be the effect upon the manufacture and sale of farm implements? Upon the purchasing ability of farmers for supplies? Upon merchants and manufacturers? Upon living expenses for the people of the country?

6. From what you are able to learn by a visit to the nearest canning factory (or from books) briefly describe the steps in the processes of canning corn from the time the corn is delivered at the factory till the cans are packed in boxes for shipment.

7. Of what use on the farm is a *silo?* Explain why great care must be exercised in its construction. What fodder is used for filling silos? Of what special advantage to the dairyman is the use of *ensilage?* What prevents the rotting of the material stored in the silo?

8. Briefly retell the steps in the manufacture of corn starch as described in some reference book. Name some uses of starch in the home.

9. What is *glucose?* How is it made? What uses has it?

10. Name some of the corn breakfast foods. In general, how are they prepared? In what other forms is corn used as a food for men?

FRUIT AND APPLE RAISING AS AN INDUSTRY

1. In a column write a list of the various fresh fruits that may be purchased at certain times during the year at fruit stands and grocery stores in your home town. Underscore the names of those grown in your immediate vicinity. After each of the names of the others write the country or section where it is grown for market. In a third column write the prevailing price for each fruit in season.

2. Explain how it is possible to ship and market in good condition such perishable fruits as (*a*) bananas; (*b*) berries. Name conditions that must be observed by shippers and fruit dealers generally so that a ready market shall be found for their fruit. Compare the keeping qualities of the orange and of other fruits in market. Account for any differences.

3. If we accept the definition that a *fruit* is the ripened product of plant growth bearing the seeds of that plant, what so-called vegetables come into the list of fruits? Of what use are the seeds produced by plants? Describe ways in which various plants secure the dispersion of their seeds. What is true with regard to seeds in the banana, and in some oranges? Describe the propagation of these fruits. Make a list of a half dozen plants that could be propagated without seed production by them, and state how this might be accomplished. What would be true of plants generally if no seeds were to be grown for several seasons in succession? What effect on mankind would failure of plants to produce seeds have? Give some examples to show this.

4. Fresh apples when cut and exposed to the air soon turn brown. Why are evaporated apples so white? What is true of the relative degree of preservation of the flavor of apples when dried and when canned? About what per cent of an apple is water? Account for the shriveling of apples kept in a warm basement.

5. About what should be the age and size of trees to set out for an apple orchard? What is the cost of standard varieties of such trees at the nearest reliable nursery? How many years before apple trees are likely to bear fruit?

6. What does the nurseryman mean by "seedlings"? What has to be done with them in order to be sure of the kind of apple borne by the tree when grown? Describe this process. Account for the different varieties of apples. How have these been improved? Why are crab apple trees often used as the "stock" into which the *scions* of improved varieties are grafted?

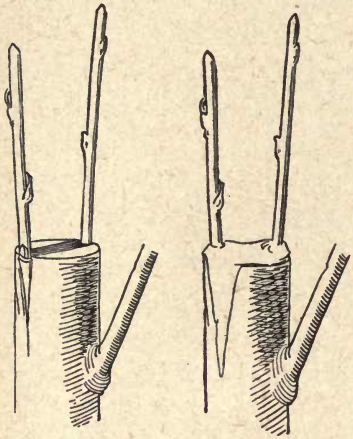


FIG. 67. — Grafting fruit trees.

7. Describe a suitable preparation of ground for setting out an orchard. What care must be exercised with the young trees at the time of transplanting? What is the best time of year for setting out apple trees in your section of country? About how far apart should apple trees be set? Why not closer? Calculate the number of trees per acre (a strip ten rods wide by sixteen rods long). In what ways may profitable use of this ground be made in the years before the trees are large enough to bear fruit freely?

8. About how many bushels of marketable apples may be considered a satisfactory yield for a tree in full bearing? That will be how many bushels per acre? At retail prices on the local market calculate the value of the crop per acre. After apples are sold from the orchard, what charges increase their cost to consumers?

9. About what time of year do apple trees blossom? What course is followed in large orchards to prevent loss of the season's crop by a late freeze in the spring? About when are the earliest varieties of apples on the market for eating? How is it that these kinds ripen so much earlier than some other kinds?

10. Does every blossom of the springtime yield an apple in autumn? If this were so, what would be the results (*a*) in the size and quality of the apples; (*b*) for the tree itself? What course is pursued by some growers to get exceptionally fine fruit? Why is this not done by all apple raisers?

11. What special care must be exercised in harvesting apples? Why are boxes preferred to barrels for the larger, finer fruit? Why does wrapping each apple separately in paper aid materially in its keeping qualities? Explain the nature of rot in apples. What is nature's protection of the apple from decay? Why do apples graded as to size and appearance sell more readily in market? What is true of the relative selling prices of these apples and of others marketed by the barrel? When apples are to be kept for any length of time, what should be true in the storage rooms (*a*) of the temperature; (*b*) of the moisture in the air? What uses are made of the apples that are undersized, misshapen, and worm-eaten? What other uses may be made of the "windfalls"?

12. Describe the *spraying* of trees in an apple orchard, stating the material used and the manner of its application. At what times in the year is this spraying done? In some way give a definite idea of the cost of doing this, including the labor.

13. How is cider vinegar made? How may this change be prevented, and the cider be kept sweet? What household uses has vinegar? How is apple jelly made?

14. In apple raising on a large scale, why is there need (*a*) of good business ability; (*b*) of considerable capital? What degree of intelligence is required to make fruit-raising a success?

WHEAT, AND WHEAT GROWING

(a) *In the Field*[1]



FIG. 68. — The "stooling" of grain.

1. About what height has the wheat plant as found in the field at the time of this lesson? About what will be its height when ready for the harvest? What advantages in the hollow growth of the stems as regards (*a*) the time that would be required for growth to the same size if solid; (*b*) the strength of a solid stem *having the same amount of material?*

2. Examine a growing wheat plant to discover if every stalk is from a separate kernel sown. What is meant by the "stooling" of wheat? Note how far below surface the crown of the wheat root grows. What advantage is there to the plant growth in this?

3. Dig carefully about a wheat plant and ascertain to about what depth the roots grow.

[1] Any field studies of growing wheat must of course be arranged to suit local conditions. See footnote under Temperature Records.

4. Make drawings of a wheat plant as a whole, showing the roots, stem, leaves, and head. In what respects is the wheat plant much like the grasses grown for hay?

5. In case the wheat seeding was done by use of a drill, what distance is found (*a*) between rows; (*b*) between plants in the row?

(b) *In the Laboratory*

1. Uproot and examine some young wheat plants, grown in moist rich soil in flower jars in the room. Compare the vigor of growth of several of the plants in relation to the apparent size and plumpness of the kernels from which they sprung.

2. Make drawings (*a*) of one of the wheat plants examined; (*b*) of a wheat head (full size); (*c*) of cross sections of a wheat kernel, both longitudinal and transverse.

3. Side by side make sketches of the heads of two varieties of wheat to show clearly the points of difference.

4. Count the number of grains rubbed out from a medium-sized head of wheat. Ascertain what per cent of those you obtain are plump and of full size. Calculate how many fold the wheat kernel from which your stalk sprung multiplied itself, allowing six stalks from one kernel.

OTHER FOODSTUFFS

(a) *Starch*

1. Remove the outside of a kernel of wheat. Examine and describe its texture, and the character of the substance within the kernel.

2. Into a piece of thin cotton cloth put a little bran, and knead it in some water in an evaporating dish so long as any milky liquid comes out through the cloth. Continue washing it at the hydrant till the water runs off clear. State the nature of what remains in the cloth, and of what has settled in the dish. From which part of the wheat kernel does each come?

3. In like manner knead some flour in a cloth. When the white solid has largely settled, pour off the water in the dish, and spread some of the solid on a filter paper to dry by evaporation. Crumble the dried solid later and state what it resembles.

Heat some of this solid with a little water in an evaporating dish till the water boils. Wet a strip of filter paper in the

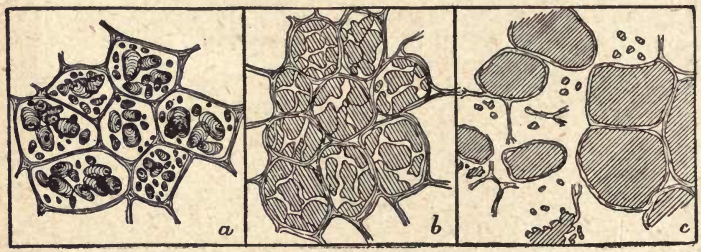


FIG. 69. — Effect of cooking upon starch granules. Cells of raw potato are shown in *a*, and when cooked in *b* and *c*.

solution, and let fall drops of iodine solution at different spots on the paper. Note the characteristic blue of the test for the presence of starch.

4. In the same manner as in paragraph 4 under Eggs, test some of the *gluten* (substance left in the cloth from the flour). What is the result?

It is to be kept in mind that the protein of plant growth (such as gluten), and of the animal foodstuffs (such as albumen of eggs, casein of milk, the fibrin of meat), are principally tissue-building material, while starch and the sugars are chiefly body fuels.

5. When to some baking soda in a test tube hydrochloric acid was added a little at a time (paragraph 4 under Carbonates), what gas formed?

Mix thoroughly a very little baking powder with a teaspoonful of flour. Make a thick dough out of it with cold water; knead it well with the fingers, and then bake it in a spoon. Explain the "rising" of the loaf. Why does the loaf retain its shape?

6. Dissolve some baking powder in a little water and heat to boiling. Observe the character of the liquid when rubbed between the fingers, and infer its meaning. Wet a strip of filter paper in the liquid, and test with the iodine solution.

(b) *The Sugars*

1. Describe all changes as the teacher cautiously pours concentrated *sulphuric acid* into some thick hot sirup of cane sugar in an evaporating dish. The sulphuric acid takes hydrogen and oxygen from the sugar (as H_2O), leaving the carbon (C).

2. Note the results carefully when a few drops of Fehling's solution are added to a solution of grape sugar (glucose, or corn sirup) in a test tube, and the liquid is heated to boiling.

State the results when the same test is made (*a*) with a solution of cane sugar; (*b*) with a starch solution.

3. Crush and dissolve some samples of candies, and test for (*a*) grape sugar; (*b*) starch. State your results, and their significance.

ORIGIN AND NATURE OF SOILS

1. Examine specimens of quartz, feldspar, hornblende, and mica. Describe each with respect to its characteristic appearance. Be sure to take note of any differences in appearance of specimens of the same kind of mineral (usually due to admixture of other earthy material). It is to be remembered that each of these substances in a pure state is a somewhat complex chemical compound of definite composition. After becoming familiar with these type specimens so that they are readily recognized at sight, identify any specimens that may be assigned you by numbers only.

2. Examine specimens of several different kinds of *granite*, and be able to point out in them particles of quartz and feldspar, as well as any hornblende and mica (if present).

Examine specimens of "weathered granite." State which of the constituent minerals seems to possess greatest resistance to decomposition.

Whether at the seashore or inland, and however extensive its amount, *sand* may be considered as quartz particles derived from granitic rock. *Clay* is feldspar decomposed. Explain how it is that clay and sand, possibly from the same rock sources, are frequently found as deposits entirely distinct, and often widely separated. Account for *sandstone* as a rock. Explain why it is that sandstone so often exhibits a stratified form (an arrangement in layers).

3. Rub some dry clay between the thumb and finger. With a magnifying glass note in a general way the size of the clay particles as seen when scattered over the surface of white paper.

Wet some clay in an evaporating dish, and then note its feeling and odor when rubbed between the fingers. Note the odor and feeling of *shale* and of *slate* when wet.

SOIL CONDITIONS FOR PLANT GROWTH

1. Recall (*a*) the definition of solution; (*b*) why substances remain undissolved. Test the solubility of bits of crayon and of limestone (*a*) in water; (*b*) in hydrochloric acid. Explain any differences in their behavior.

Whence comes the water in the sap of plants? How is it possible for food materials in the *soil* to get into the plant for its use in growth and fruitage? What change in a substance in the soil must often precede its solution by the soil water?

2. Observe the surface of any piece of stone that has been dipped into water. Explain what is noted. If the stone is now broken into several pieces, and all these are dipped into water, what is true (*a*) of the extent of their surfaces now; (*b*) of the amount of water clinging to these surfaces?

Break a blackboard crayon into piece after piece; fit the several pieces together again, and then separate them anew. What is manifest as to the extent of exposed surfaces of the crayon before and after it is broken into pieces?

What would seem probable of the amount of exposed surface, and of the adhering film of water (*film-water*), if division of rock materials should be continued to the size (*a*) of sand; (*b*) of dust particles?

3. Have three test tubes about one third full and well settled by jarring, one with coarse sand, one with *loam*, and one with *silt*. Into each pour the same amount of water,

enough to stand above the surfaces. Shake all well, let settle fully, and then drain off the water into separate dishes. Measure the amount of such drainage in each case. Explain any marked difference.

4. Put into a test tube a half inch of soil that apparently is dry, and heat it gently. Watch closely for any evidences of moisture in the tube as the heating is continued, and explain.

Examine some soil that feels and looks moist. Just where in the soil is this water, and how is it held in place?

5. Weigh out several grams of apparently dry soil in an evaporating dish. Heat it gently, stirring all the time, and

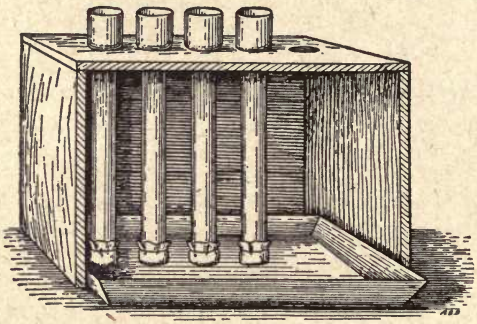


FIG. 70. — Rise of soil water by capillarity.

be careful not to char or cause other change in it than to drive off any water in the sample. Weigh anew, and calculate the per cent of loss of moisture from the soil when dried.

6. Let pieces of cheesecloth be tied over the small ends of three student-lamp chimneys, and have one chimney filled with sand, one with loam, and one with silt. Have the contents of the chimneys made compact by jarring.

Arrange the chimneys so they are supported upright with their lower cloth-covered ends in a pan containing about an inch of water.[1] From time to time observe the upward rise of the water into the chimneys by capillary action, both its elevation and its rapidity of ascent. Account for any differences noted.

As the water in the surface layers of soil in the field becomes exhausted by plant growth, or by evaporation, whence may it be replenished without rainfall, and how?

7. Counterbalance two baking powder cans that have been filled somewhat more than half full of moist soil made compact by jarring, the top of the soil in one of the cans having a half-inch layer of fine dry loam (or some dust). Observe the scales from time to time through a day or two as they are left undisturbed. Interpret the significance of any loss of equilibrium. What relation has this to the cultivation of crops during the growing season?

8. Watch closely for the escape of any bubbles of air from a test tube one half full of soil as an inch or more of water is poured in upon the soil, and account for the bubbles. What is a possible cause of the dying of plants in pots where any excess of water poured in cannot drain off. Account for a possible crop failure on low grounds in wet seasons.

USEFULNESS OF PLANTS TO MAN

1. From your own personal experiences, and from any other sources of information, prepare lists of four items each

[1] Through the upper side of a box from which the front has been removed bore holes of a size such as to allow the small ends of the chimneys to pass and to hang suspended in full view.

(*a*) of substances used in houses for fuel and lights; (*b*) of foods eaten uncooked; (*c*) of food material prepared for table use by cooking in the home kitchen; (*d*) of canned goods; (*e*) of drinks other than water; (*f*) of raw materials for clothing; (*g*) of articles of furniture; (*h*) of materials having large use in building houses.

In these lists underscore the names of all those substances derived directly or indirectly from plants. (Be ready to



FIG. 71. — Our next year's clothing.

state in class just how this is in all cases where the origin is not clearly apparent.)

2. Tell briefly but very definitely the dependence of people upon plants, and upon the products manufactured from them, in matters (*a*) of travel; (*b*) of medicines; (*c*) of livelihood; (*d*) of comforts of life; (*e*) of pleasant surroundings.

3. Name regions of the world where little or no plant life exists, and state briefly the reason for each such case. What is true of animal life there? What food supplies are available there for men? What material is to be had there (*a*) for dwellings; (*b*) for clothing?

As an example of the usefulness of plants to man, gather by reading and from all available sources as full information as possible of the plants from which the crude rubber is obtained, the processes involved in their cultivation, the harvest and preparation of this material for market, and its processes of manufacture.

4. Under appropriate headings, make lists of the various manufactured articles into which rubber enters for use in modern life.

5. State very definitely the processes of rubber manufacture from the crude gum of the rubber fields.

6. Tell briefly of the care and cultivation of the rubber plantations, and of the general character of the regions that are the chief sources of rubber supply.

XIII. WORK AND MACHINES

MEANING OF THE TERMS WORK AND ENERGY

1. Hold a book out at arm's length for a few minutes. What sensation is noticeable in your arm after a time? Regardless of the fatigue and exhaustion experienced in this exercise, it is only when motion occurs in bodies, or in the particles composing them, that the term *work* as used in Physics is applicable. There was work done in changing the position of the book but not in holding it in place.

2. Why do the muscles of the body become tired (fatigued) through exercise when at labor or play? Do machines such as the steam engine become weary when at work? What does result in them from continued use?

3. Name several changes in bodies caused by the action of forces upon them. In which of these cases is work done, and why so?

4. What is the basis for a belief that there is any such force as gravity? How does an intending purchaser of a horse assure himself that the animal has sight (good vision)? What is the meaning of the term *theory* as used in science, and in the affairs of life? What must be true of any belief, opinion, or theory if we are justified in continuing to cherish it? When must a theory be modified or rejected?

MEASUREMENT OF WORK AND ENERGY

1. With a spring balance lift some small body; note its weight in pounds (and sixteenths of a pound). This value represents not only the quantity of matter in the body, *i.e.*, its mass (m), but as well the value of gravity as a force (f) pulling down on the mass, and the *resistance* (r) overcome in lifting the body. In the measurement of work, as well as of the energy used in doing that work, one of the units employed is the *foot-pound*. This is often defined as the amount of work done (and of energy used in doing it) when a *force of one pound causes motion through one foot distance*. State a corresponding form of definition for work when the term *resistance* is substituted for "force," and the phrase *is overcome* takes the place of "causes motion."



FIG. 72. — Work is the "overcoming of resistance."

2. Calculate the number of foot-pounds done when the reading of the balance is $1\frac{5}{16}$ pounds, and the distance the body is lifted is 16 inches ($1\frac{1}{3}$ feet).

3. Drag the same body along the table through the same distance of 16 inches, and as accurately as possible get the balance reading for the *resistance overcome* (and of the *force used* in overcoming the resistance). In calculating the work now done in moving the body, why is it not the same amount of work as before?

4. Calculate anew as in paragraphs 2 and 3 above, but this time take the balance readings in *grams* for whatever body is used, and let the distance moved be in *centimeters*.[1] Let the product of the weight (force, or resistance), and the distance (or space), be *gram-centimeters* of "work" (or of "energy" used in doing the work).

5. Express the number of grams above as *kilograms*, and the number of centimeters as *meters*.[2] Then calculate the amount of work done in *kilogram-meters*.

CLASSES OF LEVERS

1. By means of a lever clamp support a meter stick at its middle point. Using loops of string over the ends of the meter stick, support any small weight near one end, and pull down sufficiently on the other end with a spring balance to keep the bar (lever) horizontal. Move the weight (W) to different distances from the point of support or fulcrum (F), and in every case note and record both the balance reading (P) and the distance from P to F. For several of these positions of P and W get the product of P × Pd (power-distance), and of W × Wd (weight-distance). These

[1] Balances and rulers should have both metric and English scales.
[2] One kilogram = 1000 grams, and one meter = 100 centimeters.

products are the *moments* of P and of W. Infer when a lever will be in a balanced condition, or state of *equilibrium.*

Make a drawing that shows the lever in some one of these positions, and correctly locate on it the positions and values of P and W. Label the drawing 1ST CLASS LEVER.

2. Having the lever supported as before, put both P and W on the same side of F, *and with W between P and F.* It will now be necessary to pull upward with the spring balance in order to maintain equilibrium. Calculate the moments of W and of P in different positions, and state what is true of their relative values in every instance. What is true in every case (*a*) of the relative lengths of power and weight arms (distances); (*b*) of the relative values of P and W?

Make a drawing to represent the lever in some one of these positions, and label it 2D CLASS LEVER.

3. Arrange the lever now so that the pull of the balance (P) is upward, *and between W and F.* State what is found true under these conditions (*a*) of the moments of P and W; (*b*) of the relative values of P and W. Make a drawing to represent a 3D CLASS LEVER, putting upon it the values found in some one of the cases for P and W, and for Pd and Wd.

PULLEYS

(a) *With the Cord Attached to the Fixed Pulley*

It is desirable to have a pair of "triple-tandem" pulleys as represented in the cut, and a spring balance graduated both in grams and in ounces. A length of stout, smooth cord with loops at its ends is easily provided.

1. Make two freehand drawings on your paper similar to the cut, showing in the first *one movable pulley* in use, and in the second *two movable pulleys*. In all cases represent one end of the cord attached *to the fixed pulley*.

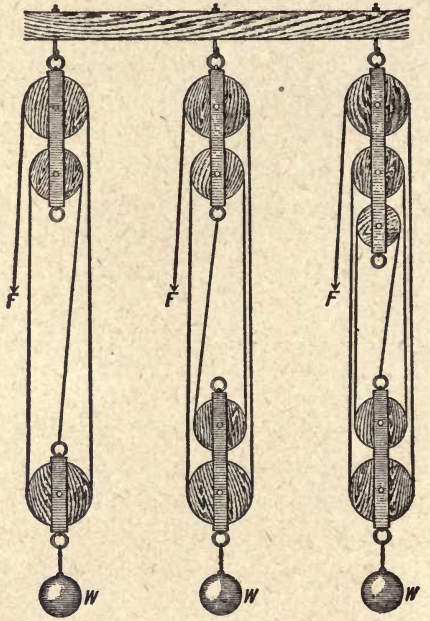


FIG. 73. — Diagram of pulleys.

2. Let the teacher fit up pulleys in turn representing these same conditions, and determine by use of the spring balance in each case (*a*) the value of the resistance overcome (*i.e.*, the weight of movable pulley and its attached body [1]);

[1] Any friction, or resistance other than gravity, is disregarded here.

(*b*) the effort put forth ("pull" exerted) to lift the body.[1] Enter on your drawings the values found by the teacher, marking the resistance as W (weight), and the effort as P (power).

Be sure to verify the correctness of your drawings by reference each time to the pulley arrangement as set up by the teacher.

3. Let the teacher take the readings of the spring balance for the value of P (*a*) *when pulling down* over the last of the fixed pulleys; (*b*) *when lifting up, and not using this last fixed pulley.* Infer (*a*) the only purpose of this fixed pulley; (*b*) whether the section of cord for pulling downward shall be counted in any case as a supporting cord for W.

4. From inspection of your diagrams, and of the values of P and W shown thereon, state what appears true (*a*) of the number of cords supporting W relative to the number of movable pulleys; (*b*) of the fractional part of W supported by each cord; (*c*) of the ratio (approximately) of W to P relative to the number of such cords.

5. Measure the distances through which P moves in all of the cases above when W is raised through a distance of one foot every time. State for each case how many times greater the power-distance (Pd) is than the weight-distance (Wd). How does this compare with the number of supporting cords in each case?

6. Since P traverses the distance Pd in the same time that W moves through Wd, what must be true of the rela-

[1] For this value of P take the *average* of the readings of the spring balance as W is drawn slowly upward, and then again as W is allowed to descend slowly. In this way the value of the resistance due to friction of the pulleys is quite largely eliminated.

tive values of the velocities of P (Pv) and of W (Wv) in all cases?

What are the relative values (*a*) of P times Pd, and W times Wd; (*b*) of P times Pv, and W times Wv?

(b) *With the Cord Attached to the Movable Pulley*

7. Make two other drawings to show the arrangement of pulleys, and the values for P and W as directed in paragraphs 1 and 2 above, *but this time with the end of the cord attached to the movable pulley.*

8. Determine the values, and state the relationships now apparent as required in paragraph 4 above.

9. Answer the same requirements as in paragraphs 5 and 6 above, with the conditions as they are now.

10. Disregarding any waste of energy due to friction, what seems true of the relative value of the work done (W times Wd), and of the energy used in doing this work (P times Pd)?

11. State some of the advantages from the use of pulleys as machines (*a*) over the direct application of any force to a body that is to be moved; (*b*) over the use of levers of any kind.

XIV. MAGNETISM AND ELECTRICITY

ELECTROMAGNETS

1. Bring first one end of a bar *magnet* and then the other to the north *pole* of a compass needle. Try the south pole of the needle in like manner. State what appears true of the effect upon each other (*a*) of like poles; (*b*) of unlike poles.

2. Compare the number of small nails that one pole of a bar magnet will support with the number that can be picked up (*a*) when the like poles of two bar magnets are used together; (*b*) when their unlike poles are together.

3. Put a bar magnet across one pan of a balance, and counterpoise it. Bring close above its north pole the south pole of another bar magnet, and state the results. What is all the time true of the weight of the magnet? Account for what occurred.

Bring the balance into equilibrium. Repeat the test, bringing like poles together. Explain the result.

4. Observe closely as the teacher connects a "dry cell" to the ends of the coil of an *electromagnet*, and tests the effect of the magnet upon nails.

Determine by trial which is the north pole of the electromagnet while connected with the *cell*. Mark this pole N. Then connect the coil with the cell so that the *current* is sent through the coil in the opposite direction, and test the polarity anew. State all the results.

5. Note about how many nails the electromagnet supports when the current is passing through the coil. As carefully

as possible let the connection with the cell be broken, and note the effect. Repeat several times to be sure of the condition of the coil as the *circuit* is (*a*) opened; (*b*) closed. State the results.

6. Observe closely the results when the teacher connects a dry cell to an *electric bell* in working order. (Use two cells if necessary.)

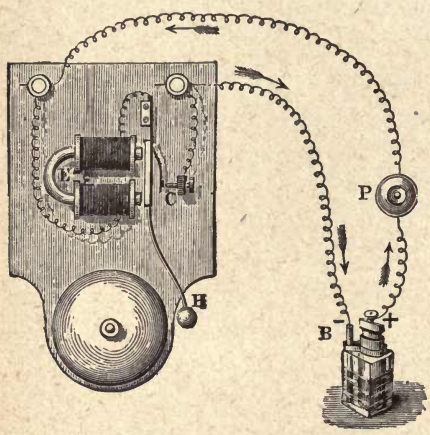


FIG. 74. — The electric bell, and how it operates.

Describe the course of the current through the bell, tracing it very carefully with such assistance as may be needed.

Notice the effect on the hammer of the bell as the circuit is closed and opened. Explain (*a*) why the hammer is drawn towards the coil; (*b*) why it flies back from the coil. Explain how the "make and break" of the circuit is accomplished automatically with the battery connections continuously maintained.

State several possible causes why electric doorbells may fail to operate. What may be done to locate the particular cause of trouble in order to remedy it?

7. Connect a *telegraph key* into the circuit between the battery and the bell; make use of it to close and to open circuit, thus ringing the bell at pleasure. Describe the

connection through the key, and explain the use of the key.

8. Substitute for the bell a *sounder* from a set of telegraph instruments, and by use of the key cause the sounder to operate. Describe the course of the current through the sounder, and its manner of operation as the circuit is closed and opened. State (*a*) when the sounder might operate so feebly as to make it impossible to read its clicks distinctly; (*b*) two ways in which to remedy this.

ELECTRICITY, AND CHEMICAL CHANGES

1. Fill the tumbler of a simple *voltaic cell* as shown in the cut two thirds full of water. Have both the zinc and the copper strips of metal scoured bright with sandpaper. To the water add sulphuric acid a few drops at a time till, as the water is stirred with the zinc strip, bubbles form on the metal surface somewhat freely. These are not air bubbles, but the gas is hydrogen formed as result of chemical change between the acid (H_2SO_4) and the zinc (Zn). It has been found by tests made very many times

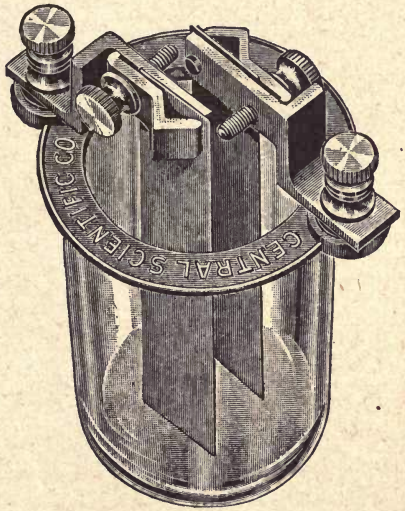


FIG. 75. — A simple voltaic cell.

that there is formed at the same time one other substance, zinc sulphate ($ZnSO_4$), which, so long as the water can hold it in solution, dissolves as fast as it forms. When the water becomes saturated (filled) with it, the $ZnSO_4$ will then be deposited as a solid.

2. Chemists have a shorthand way of stating chemical changes *known to have taken place*, and in this case the statement would be $Zn + H_2SO_4 \rightarrow H_2 + ZnSO_4$. The arrow points toward the products of chemical change, and in these products there must always be the same weight of material (and same numbers of atoms of the substances) as found in the substances entering into the change.

3. Test the action of the dilute acid, (*a*) using the copper (Cu) strip in place of the zinc; (*b*) putting both strips down into the liquid at the same time *but not allowing the metals to touch each other* either within the liquid or outside.

4. Fasten in place in the cap of the simple cell a strip each of copper and of zinc. Connect the binding posts in contact with these strips by a copper wire a couple of feet in length. Now put the cap in place on the tumbler with the metal strips in the liquid close together *but not touching each other*. Observe the strips in the liquid long enough to state what change from the former conditions is now noted.

5. Bring the wire connecting the binding posts down *lengthwise* over a compass needle which is at rest in a north and south direction, and note the effect. Repeat several times to be sure whether any disturbance of the needle results *from the presence near it* of a current-bearing ("live") wire. Note the effect on the compass needle of bringing near it and of taking away a permanent magnet. Try a

piece of iron; then try other substances. Since the wire is copper (not iron), what seems to be a characteristic of a wire in which a current of electricity is passing?

6. Repeat the tests upon the compass needle, but this time use a dry cell with its binding posts connected by copper wire. State the results, and their significance.

7. Cut the wire, joining the binding posts of the dry cell, in the middle, and test the effect on the compass needle of the wires of the "broken circuit." Bring the ends of the wires together on either side of a thickness of paper, and determine if the current completes a circuit through the paper.

8. Connect the ends of the wires fastened to the binding posts of the dry cell to the binding posts in the cap of another simple cell into which two copper strips have been fastened. These copper strips are now the terminals of a broken circuit. Put these strips down into a second tumbler containing some water, being careful to keep them near each other but not touching. By bringing one of the connecting wires down over the compass needle at rest, determine if the circuit has been closed *through the water*. To the water add a little sulphuric acid and, after stirring the liquids well, test the effect of the wire on the compass anew. The acid serves as a carrier of electricity across from one terminal to the other, and is said to be an *electrolyte*. Many substances in solution would behave in a similar manner, but not all solutions are electrolytes.

9. Repeat paragraph 8, but this time use with the water a little copper sulphate ($CuSO_4$) for the electrolyte. After some time with the circuit closed examine the copper plates for changes in appearance.

XV. PHENOMENA OF LIGHT

SHADOWS AND ECLIPSES

1. Let the room be darkened, and a lighted candle so arranged that a well-defined *shadow* of some opaque body is made to fall on a white wall-surface or other screen. By moving a sheet of paper back and forth between the screen and the body determine how many dimensions a shadow actually has, *i.e.*, whether a shadow is a darkened region (space) or a darkened surface. That which is seen on a screen or wall bears what relation to the real shadow? If there had been no screen across the path of the shadow, what would have been true of its extent outward?

2. Note if there is any sharp line of division between the *umbra* (dark part of the shadow) and the *penumbra* (the lighter outer portion). Determine if the umbra extends lengthwise throughout the shadow region.

Support a sheet of paper so that a pinhole through the paper may be moved in turn through the umbra, the penumbra, and then outside the darkened area. By looking through the pinhole towards the candle flame determine (*a*) the reason for the existence of any shadow; (*b*) the cause of the distinction between umbra and penumbra, and why they merge without a sharp line of division.

3. Make such arrangements that enough direct (or reflected) sunlight may come into a darkened room to strongly illuminate a small ball that is to represent the earth.

By use of a sheet of paper moved back and forth in the shadow cast by the ball, determine (*a*) the form of the shadow region; (*b*) its extent outward (length); (*c*) the form of cross section at right angles to the direction of the shadow; (*d*) where the base of the shadow is. Leave the screen supported in some way in the path of the shadow so that cross sections of both umbra and penumbra show upon it.

4. Making use of a small marble to represent the moon, cause it to move round and round the ball in a path (*orbit*) that at times passes (*a*) through the umbra of the shadow; (*b*) only in part into the umbra; (*c*) through the penumbra only, or wholly outside the shadow in the region of illumination.

State the conditions that apparently must exist (*a*) for total *eclipses* of the moon; (*b*) for partial eclipses; (*c*) for failures to have a lunar eclipse every month. From which side of the earth with reference to the sun are eclipses of the moon to be seen? During which part of the twenty-four hours will this be for the observer?

5. As the marble (representing the moon) is moved around the ball, try to visualize (*a*) the revolution of the real moon about the earth, and in a path such that it comes between the sun and an observer; (*b*) the onward sweep of the moon's shadow across the earth's surface as it approaches the observer, envelops him in an "eclipse of the sun" and passes on to the eastward beyond him. In so-called eclipses of the sun, what really suffers eclipse, *i.e.*, passes into shadow? What must be true of the duration of a solar eclipse at any station?

In what part of the moon's shadow must an observer be

that an eclipse of the sun is total rather than partial? What change in the moon's distance from the earth when it is directly in line between an observer and the sun will result in its not wholly covering the sun's disk? The moon will then appear as a dark body, and the sun as a ring of light all round the moon's edge — an *annular* (ringlike) eclipse. Make a diagram showing these conditions.



Fig. 76. — Diagram showing conditions for solar and lunar eclipses.

6. Total solar eclipses are very rare occurrences for any one locality on earth. What evident connection is there between this infrequency and (*a*) the length of the moon's shadow; (*b*) the size (cross section) of the umbra near its apex?

7. From the diagram above find the apparent reason why the moon gets into the earth's shadow (lunar eclipse) more often than an observer on the earth is in the moon's shadow (solar eclipse).

8. The period of the earth's revolution about the sun is somewhat more than 365 days, while that of the moon about the earth is 28 days. How many full moons per year are possible? How many total eclipses of the moon? Ascertain from the almanac (or otherwise) how many are to occur during this calendar year? Why are there no more?

9. Make a drawing that shows the sun, the earth and its moon, and Jupiter with at least one of its moons, so arranged as to represent: —

(*a*) Shadows cast by both Earth and Jupiter, and by the satellites of both planets, with positions such that eclipses of the moons are about to occur in both cases.

(*b*) The earth's moon in such a position that an eclipse of the sun is about to occur.

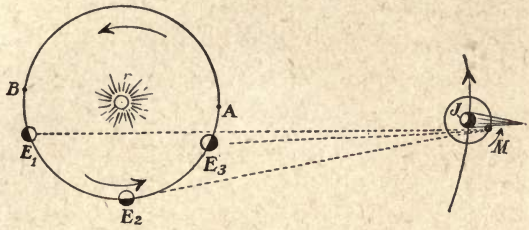


FIG. 77. — The velocity of light was calculated from observations made by astronomers of the time-intervals between eclipses of the inner satellite of Jupiter.

10. Astronomers tell us that the innermost of the moons of Jupiter is eclipsed at every revolution. Tell several astronomical conditions implied in this statement.

IMAGES BY REFLECTION

1. Hold a small looking-glass in the sunlight at a window and state the effect (*a*) on the direction of light as it comes from the sun; (*b*) on the degree of illumination where this *reflected* light now falls. Distinguish between *incident* rays and reflected rays.

2. Hold a mirror so that the reflected light of a candle flame enters the eye. What is seen in the mirror? Call it an *image* of the flame. Along which rays of light is this to be seen? Why is it seen in this particular direction and not in some other?

3. With a lighted candle close in front of a looking-glass, how many flames are to be seen? Where does the one that is not a real flame seem to be?

4. Set the lighted candle so that it shall be hidden behind a book, but let its image be in sight. State the course of the light from the candle flame to the eye.

Attempt to take hold of what seems to be a candle image behind the glass. Move a screen (a sheet of paper) back and forth where it seems to be. What is true of the reality of this candle image? Call it a *virtual image.* What kind of surfaces form these images? What is the effect of such surfaces on the light that falls upon them?

5. Hold a lead pencil with the point towards the glass. In what direction does the pencil image point? As you look in the glass, touch your right hand to your right ear. Which hand and which ear of the image seems to be employed? (The image is reversed, *i.e.,* turned right and left.) What is the relative size of the object and image?

6. In front of a looking-glass lay a foot rule perpendicular to the mirror. How far back of the mirror does the image of the 3-inch mark appear to be? How far back, apparently, is the 5-inch mark?

7. On a sheet of paper set a mirror upright (on edge), and near it place a ruler somewhat oblique to the mirror surface. Draw lines along both the mirror front and the marked edge of the ruler. Locate on the latter the 2-inch and 4-inch marks.

Remove the paper, and draw lines from the 2-inch and 4-inch marks perpendicularly through the mirror line for some distance. Replace the mirror and rule, and note where such

perpendicular lines (*normals*) appear to pass with reference to the images of the 2-inch and 4-inch marks.

8. Draw a line on a sheet of paper to represent a mirror surface, and in front of it a 3-inch arrow oblique to this line. Having in mind what is suggested in paragraph 7, locate the image of this arrow on the other side of the mirror line by use of ruler and protractor.

COLOR PHENOMENA

Note carefully the procedure as the teacher follows out the directions given below. Be ready to state the results obtained, and the significance of them as called for in turn.

1. So adjust a triangular glass *prism* in a beam of sunlight as to get a solar *spectrum* on a white wall of the room (or other screen). Then darken the room. By use of a strip of card put over the prism faces, determine (*a*) through which face the incident light enters; (*b*) through which the light emerges. Call the edge formed by the intersection of these faces the *refracting angle* of the prism, and the side opposite it the "base" of the prism. Note (*a*) whether the change in direction of the incident

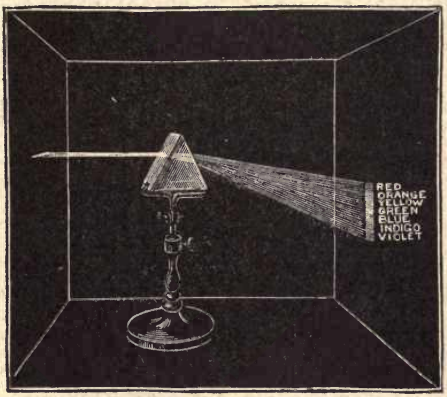


FIG. 78. — Dispersion of light, and the solar spectrum.

rays is toward the base, or away from it; (*b*) which of the colors of the spectrum is bent farthest around, and which least. Name these colors of the solar spectrum in order, beginning with the red.

A spectrum, whatever the source of light, is defined as *an arrangement of colors in the order of their refrangibility, i.e.*, according to the degree they are bent from a straight line by refraction. *Refraction* of light by definition is a bending of the rays, *i.e.*, a change in the direction of light, by reason of changes in the density of medium. (As from air into glass, and then from glass into air.)

2. Using a sheet of writing paper that has been dipped into hot melted paraffine to make it *translucent*, trace the emergent rays outward from the prism and note (*a*) what their relative direction is after refraction; (*b*) why it is that refraction commonly occurs without noticeable dispersion.

3. Let some one on the far side of the room look through a long narrow opening in a cardboard held for him in the different color parts of the spectrum in turn, and tell in each case what the color sensation is.

4. Let the spectrum fall upon a plane mirror, and note (*a*) what is done to the light waves giving the spectrum colors; (*b*) whether there has been any change in the relative positions of these colors. Explain how it is that all of these different colors (light waves) come to every one of you, although you are seated in different parts of the room.

5. Hold a narrow strip of blue cardboard (as pure blue as obtainable) in different parts of the spectrum, and note its changes in appearance. It is explained that any *pigment* (the material upon which the color of a body depends) re-

flects some waves (colors) more largely than others, and absorbs the different color elements incident upon it in varying proportions.

Repeat the tests, using in turn cards of different colors. (Get as nearly pure colors as can be had.) Explain the results as phenomena of *selective absorption.*

Explain (*a*) the green of the grass; (*b*) the yellow of gold; (*c*) the white of any painted house.

6. With a piece of blue (cobalt) glass so held that light from the window comes through it to you, explain *selective transmission.* In like manner use a piece of red glass, and explain.

Now put the two pieces of red and blue glass together, and between you and the light from the window. Account for the results.

Observe the spectrum on the screen as first the blue glass is put near the prism in the path of the emergent rays, then the red glass, and then both glasses. What is the explanation of these results?

XVI. THE EARTH AS A PLANET

DAY AND NIGHT, AND THE EARTH'S ROTATION

1. When the sun rose this morning, in what direction was it from due east? (Be ready when called upon to point out where the sun rose.) About what time was it? What is the time now?

Where is the sun now? What has it done (apparently) since you first saw it this morning? In what direction will it be at sunset to-night? Why do you think so? What do you ordinarily mean by (*a*) sunset; (*b*) sunrise?

Where will the sun be to-morrow morning? Why is it reasonable to expect this?

2. What is the common distinction between daytime and nighttime? Why is the nighttime better for sleep, and the daytime better for our varied activities? Name some occupations in which men labor all night, and sleep by day.

How many hours in a day (both daytime and nighttime)? From what time to what time may the length of a day be best measured? What fractional part of such a period is an hour? How are the lengths of minutes and seconds determined? Calculate how many minutes there are in a day (24 hours).

3. Hold a cardboard edgewise against the right side of the face, thus shutting out of sight objects far around on that side. Turn slowly towards the right without change of standing place, and state (*a*) what is found true of the

angular distance of any visible object from the direction (*plane*) of the cardboard as you turn more and more; (*b*) what is found true of the relative distances apart at different times of any two objects in sight; (*c*) how far around one must turn that an object shall apparently have moved 90 degrees from the plane of the cardboard.

4. Repeat the above but with cardboards extending outwards from both sides of the face. State (*a*) when an object may be said to "set"; (*b*) how far around one must turn that an object which has once "set" may "rise" again; (*c*) the significance of saying that an object thus coming into view, and then disappearing behind the cardboard *horizon*, has an "apparent motion"; (*d*) where the real motion exists.

5. What do you mean by the east horizon of any observer? By the west horizon? What prevents our seeing the sun when it is below the west horizon?



FIG. 79. — The horizon at sea.

Instead of thinking of the sun as moving down below the west horizon at nightfall, think of the sun as standing still. Account for the so-called "setting" of the sun. What does "sunrise" really mean?

6. Use a sphere with a heavy wire *axis* to represent the earth, and by means of a thumb-tack fix a spot on the sphere that represents your position as an observer in the northern hemisphere. Let this same tack hold in place for an horizon plane a circular cardboard sufficiently large to have the

wire axis reach up through and above it. Turn the sphere together with this cardboard horizon on the wire as an axis, *i.e.*, rotate the sphere. Note that the east horizon (front edge) falls lower and lower below objects which were at first out of sight of an observer as located by the tack, thus causing them to "rise." Note, too, that the opposite (west) horizon of the cardboard passes objects and shuts them from view, causing them to "set" for the same observer.

Explain (*a*) how this exhibits succession of daytime and nighttime on the earth; (*b*) how it is that when we have nighttime, and can see the stars, there are people elsewhere in the world who are having daytime.

7. With the sphere and a lighted candle, but without the cardboard, note how by turning the sphere on its axis the marked place of the observer's position comes around on the side where the light is, then passes through the region of illumination (daytime), and then on for a period (nighttime) when the light cannot be seen.

Repeating such rotation, state when for the observer on the earth there occurs (*a*) sunrise; (*b*) noonday; (*c*) sunset. State (*a*) how often these occur; (*b*) when a day's period is completed. Why is the sun not seen at all times?

8. Define for a rotating body (*a*) axis; (*b*) poles; (*c*) equator; (*d*) *parallels of latitude.*

9. Repeat paragraph 7, holding the sphere so that the illumination reaches from pole to pole. State where a line drawn from the source of light to the center of the sphere cuts the surface of the sphere. Letting the light represent the sun and the sphere the earth, state where on the earth

the sun would thus be directly overhead as the earth turns on its axis.

State the relative lengths of the path of the observer through the illuminated and the unilluminated regions, and of the day and night periods for the observer.

ROTATION COMBINED WITH REVOLUTION, AND CHANGES IN SEASONS

Upon a crayon box on the table support horizontally an ellipse that has been cut from heavy cardboard. Its *major axis* (long diameter) should be at least two feet, and its sides so slightly flattened that it is very nearly a circle. Let its circumference represent the earth's path around the sun (the earth's orbit). Into a hole a little at one side of the center (and toward one "end") crowd a marble nearly halfway through to represent the position of the sun in the earth's orbit.

1. What is meant (*a*) by an *ellipse;* (*b*) by the *revolution* of a body as distinguished from *rotation?* Around this elliptical circumference carry several times the sphere that represents the earth, always observing, however, these two directions: —

I. Have the sphere tipped northward so that its axis makes an angle of approximately $23\frac{1}{2}°$ with a perpendicular to the cardboard. (This tips the axis about one fourth way over from a vertical position.)

II. Keep the direction of the axis, no matter where the sphere is placed, at all times parallel to this first direction. This makes it at all times point towards the North Star in the heavens.

2. Adjust the ellipse so that when the sphere is placed at the end of the major axis nearer the marble, the north pole of the sphere (earth) is tipped away from the marble (sun). Then state: —

(*a*) Where vertical rays from the sun (direction from center to center of spheres) fall on the earth relative to its equator.

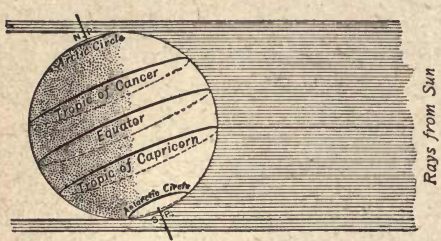


FIG. 80. — December 21st.

(*b*) What circles on the earth are marked out by these vertical rays, and by those rays reaching farthest north and farthest south, as the earth is made to rotate?

3. Move the sphere representing the earth a quarter way round the cardboard to the right (as one faces the center), observing all the requirements of I and II in paragraph 1 above. State what is now noted as required in (*a*) and (*b*) of paragraph 2.

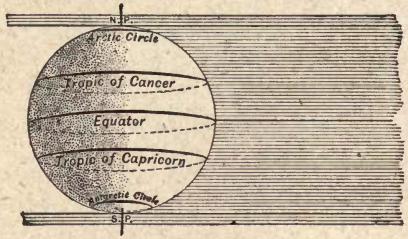


FIG. 81. — March 21st, and September 22d.

4. Move the sphere to the other end of the major axis, and farthest from the marble. State as in paragraph 2, (*a*) and (*b*).

5. Move the sphere on to three quarters of the way around the cardboard, and state as above.

6. When a complete revolution of the earth about the sun is accomplished, what period of time has elapsed? In the northern hemisphere, what season of the year is represented by each of the four positions of the sphere?

7. State in detail why these changes in the position of the earth in its orbit cause changes of seasons for us.

8. Let a sheet of paper, whose edge is cut out to fit down over the sphere, be so adjusted perpendicular to the cardboard that it marks the separation of the regions of darkness and of illumination when the sphere is placed as in paragraph 2 above. Rotate the sphere, and note the relative lengths of the paths through the daylight and nighttime regions for an observer in the northern hemisphere.

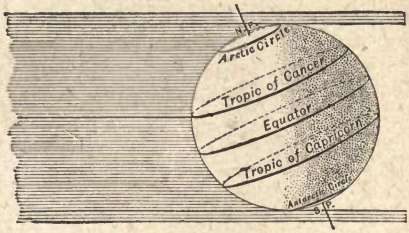


FIG. 82. — June 21st.

Do the same for the positions as given in paragraphs 3, 4, 5 above, and state what is apparently true of the relative lengths of day and night for each of the different seasons.

THE MOON, AND ITS PHENOMENA

(a) *Observations*[1]

Let every one look for the moon to-night (or on the first clear night), as early in the evening as possible, and be ready to help fill out the following "Record" from which much concerning the moon and its motions may be learned: —

DATE	HOUR	SHAPE	PART OF HEAVENS	DEGREES ABOVE HORIZON	APPARENT TIME OF RISING (OR SETTING)
—	—		—	—	—
—	—		—	—	—
—	—		—	—	—
—	—		—	—	—
etc.. etc.					

[1] See footnote of lesson on Temperature Records. It is readily apparent, too, that these studies are best begun when the moon is "new."

This record should be made at intervals of two or three days throughout a month. If the weather has been unfavorable, continue the observations for two months or more. Observe the moon's appearance as early in the morning, too, as possible.

1. On your paper make a drawing to show the shape of the moon as you saw it last. At what hour and date was this?

2. Hold at arm's length an orange from which the peel has been removed. With the same side toward you all the time,[1] turn completely around where you stand without stepping to one side. Let the revolution of the moon about the earth be thus represented in the motion of the orange around yourself as an observer.

Select some object in the room as a source of illumination (the sun). Using the shell of a half orange to cover the unilluminated side of the peeled orange (always, of course, on the side opposite the light), note very definitely the form of the white (illuminated) part visible to you as seen under these several conditions: —

(*a*) When the orange is held between the eye and the object representing the sun.

(*b*) When it is moving through the first quarter of its circular path.

(*c*) At the end of this quarter.

(*d*) When moving through the second quarter.

(*e*) At the end of the second quarter, and *opposite the sun.*

(*f*) When moving through the third quarter.

(*g*) At the end of the third quarter.

[1] One side of the moon is always away from the earth, and a large part of that side is never visible from any part of the earth at any time.

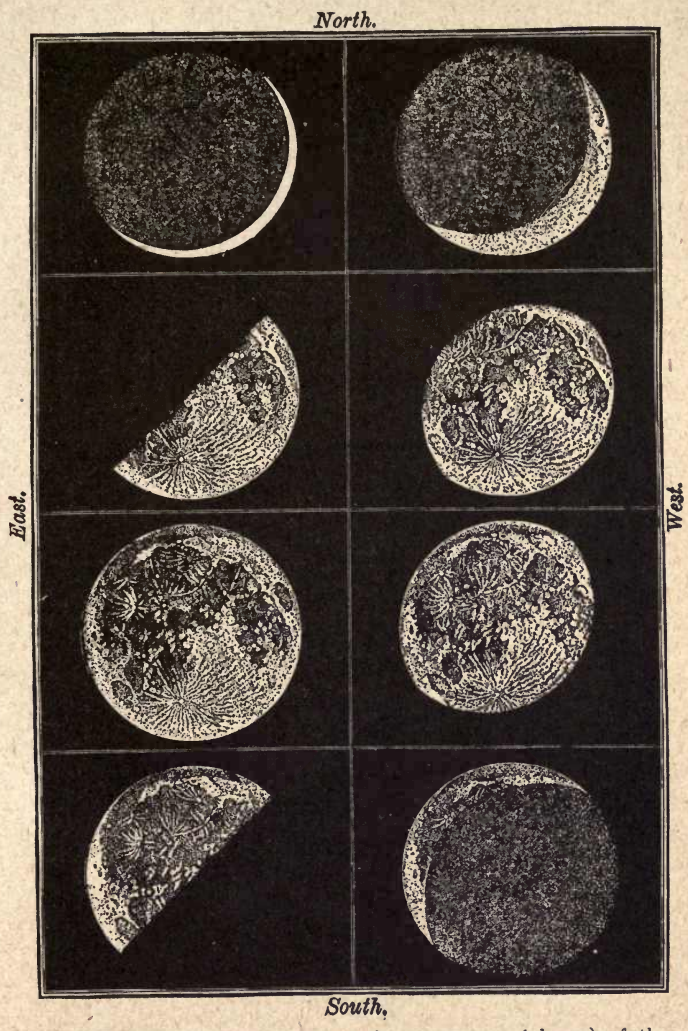


FIG. 83. — The successive changes in appearance (phases) of the moon during a month.

(*h*) When moving through the fourth quarter, *and in conjunction with the sun, i.e.*, in line with it.

Now make a series of eight drawings to show these forms (*phases*) of the moon. (Represent the outline form of the moon as a circle, and blacken the unilluminated part.)

(b) *Questions on the Data Gathered*

1. When the moon was seen in the west in the early evening, state (*a*) in what direction it was from the sun; (*b*) in what direction with respect to the sun its "horns" (*cusps*) pointed; (*c*) what was the shape of its east edge, and what of its west edge; (*d*) what was true of its distance from the west horizon (and the sun) evening after evening at sunset; (*e*) its times of setting night by night; (*f*) the direction it was from an observer when it appeared as a "half moon" at sunset; (*g*) how many *degrees* (or what fraction of a circle) the half moon is from the sun.

2. Of the full moon, state (*a*) at what time it rises with reference to the time of sunset; (*b*) what part of a whole circle of the heavens it is from the sun; (*c*) how long since the moon was "new," and how long since it was a half moon; (*d*) what is true of the times of rising night after night; (*e*) how long from one full moon to the next; (*f*) which quarter of the moon's revolution has been completed when it is full.

3. From observations of the moon made mornings before daylight, state (*a*) the changes in phase morning after morning; (*b*) the direction of the moon from the sun; (*c*) its distance from the sun morning by morning; (*d*) what must result in the course of several days as to the direction of

sun and moon from the observer; (*e*) through which quarter of its revolution about the earth the moon must have passed when seen in the morning as a half moon; (*f*) to which phase the moon comes at the end of the fourth quarter; (*g*) why the moon is not then to be seen for a time.

4. With the moon full and rising at sunset, what is the position of the earth with reference to the sun and moon? At time of "dark moon," which side of the moon as lighted by the sun is towards us? What kind of a body must the moon be with reference to giving off light of its own?

5. When the moon was new, what was its place of setting relative to that of the sun? What was true in this respect when the moon was full?

6. How many full moons may there be in a year? Account for the "months" of our *calendar*. Ascertain the relation of the date for Easter in any year to the time of full moon then.

TIME AND TIME-KEEPING, AND STANDARD TIME

1. With a string and any suitable weight arranged to swing freely from a fixed point of support as a *pendulum*, and with the length from the point of support to the center of bob about 25 inches, set the pendulum swinging through a small arc, and count the number of *oscillations* per minute. Repeat, with the pendulum length (*a*) less; (*b*) greater. Upon what does the time for one oscillation seem to depend?

2. Make the pendulum length now 36 inches, and count the number of oscillations. Find the ratio value to two decimal places (*a*) of the numbers of oscillations for the two

pendulums; (*b*) of the square roots of the two pendulum lengths. [Use smaller number for divisor in both cases.]

3. Make the pendulum length 39^{+} inches, and count the oscillations per minute.

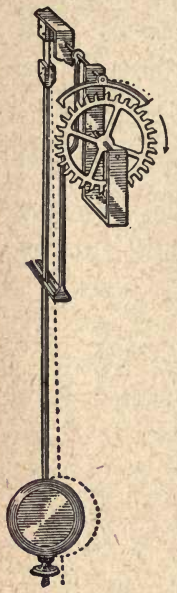


FIG. 84. — A clock escapement.

4. With a stronger force pulling the pendulum down, what would probably be true (*a*) of the rate of motion of the pendulum; (*b*) of the number of oscillations per minute? Since the force of gravity varies in different latitudes, what must be true of the lengths of pendulums to make the same number of oscillations per minute in different localities? What must be true of the lengths of second's pendulums in different places?

5. Recall the effect of temperature changes (heat and cold) upon lengths of bodies. What must be true of the pendulum length in the same clock (*a*) summer and winter; (*b*) through a day? What effect has this on the time for one oscillation of that pendulum? What means are employed to secure uniform oscillation periods for the same pendulum?

6. Secure an old clock from which the *dial* has been removed. Find the number of oscillations that allow one tooth of the wheel to pass the *escapement*. Count the teeth of this wheel. Calculate the number of oscillations for every

one turn of this wheel. From the number of oscillations per minute of the pendulum (by your watch), determine the time required for one turn of this wheel.

By counting the number of teeth of the *pinion* of this same wheel and of the second wheel into which the pinion works, calculate the time for one turn of this second wheel. In case a hand were attached to the axle of this second wheel, what time interval would be counted off by its every complete turn? What purpose has a portion at least of the *wheelwork* of a clock?

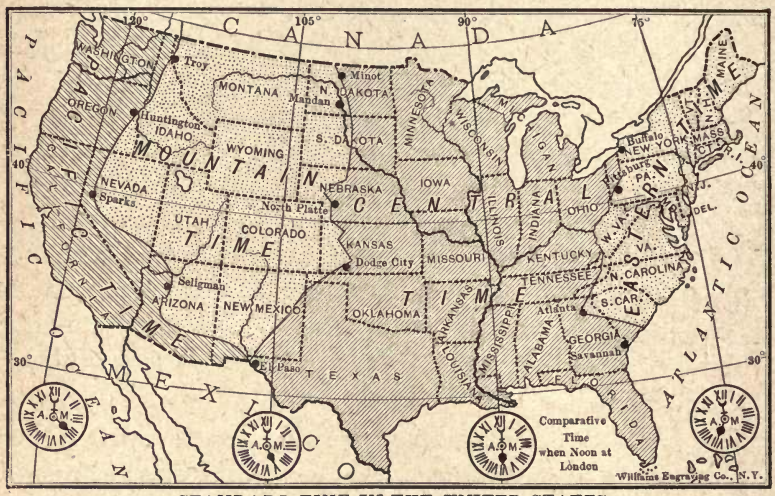
7. Note the result as the escapement at the upper end of the pendulum is pulled forward by the teacher sufficiently to free the first wheel in the train, and the effect of replacing the escapement on the rate of the wheel motion. State (*a*) the cause of the motion in the wheelwork; (*b*) the use of the pendulum with reference to such rate of motion. Recall what was true after a time of the motion of the pendulum in paragraph 1. What is true of the motion of a clock pendulum? Explain the difference. Name another use of the wheelwork of a clock. What is the sole purpose of the pendulum in the clock?

8. Calculate the number of seconds in a day. How is the natural unit of time we call the day fixed for us? From what time till what time is the true solar day measured? Since in a day there are 86,400 seconds, what will be true of the relative lengths of these equal parts if the day's length varies during the year (as it does)?

9. With 86,400 swings of a second's pendulum counting off a day-period, what will be true of noon by the clock, and noon by true solar time (meridian passage of sun)?

This difference, amounting at different times of year to values varying from 0 seconds to about 16 minutes, is the "*equation of time*" (or the "sun fast," "sun slow") of the *almanacs*. It must be taken into account in comparing clock time and sun time. Clock or "local" noon is determined from true noon by adding (or subtracting) the equation of time for what particular date?

10. What is true of noon local time for you and for places (*a*) eastward; (*b*) westward? What will be true of the



STANDARD TIME IN THE UNITED STATES

FIG. 85.

watch readings of people keeping local time in towns east and west of one another? What is meant by *standard time?*

With the sun neither slow nor fast, by what amount will a clock that keeps standard time vary from the true local time?

XVII. THE HEAVENS

1. Write the names of several *stars* known to you. Tell in what way you recognize any one of these when seen.

2. Write the names of several groups of stars (*constellations*) known to you. Represent on your paper the arrangement of the brighter stars in any one of these groups, thus showing the form by which it can be recognized and pointed out to anyone else.

3. The stars are supposed to be bodies much like the sun, and many of them vastly larger. What is the explanation for their apparent smallness, and their lack in heat and light? When only are stars to be seen, and why so? What is the number of the stars?

4. At what season of the year do the stars generally seem to be brightest? What is true of the amount of water vapor present in the atmosphere then? What commonly is the cause of any haze overcasting the sky, dimming the light of the stars or hiding them altogether? What differences are there in the appearance of stars other than brightness?

5. What significance has the rising and setting of stars, *i.e.*, what occasions it? What is the real name of the so-called "shooting stars"? What is their nature?

6. After some sufficient time (which the weather and other conditions will determine), be prepared from obser-

vations made by you (either with or without assistance) to write answers to the following requirements: —

(*a*) Whether the path of any star (or constellation) across the sky night after night is always the same.

(*b*) What is true of the places of rising (or setting) of the same star night after night.

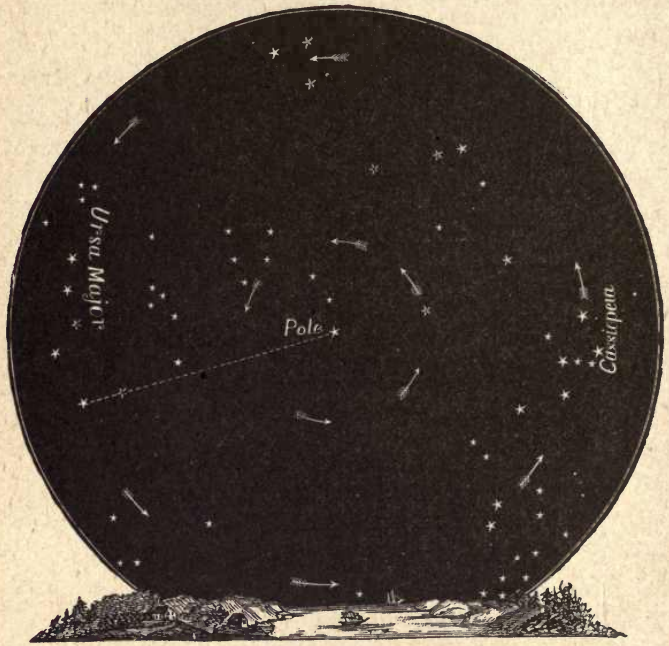


FIG. 86. — Polar constellations.

(*c*) The names of several constellations always above horizon (that never "set") to observers in your latitude.

(*d*) The appearance of the Milky Way. Its place in the sky relative to some known constellations. Its real nature.

(*e*) A diagram (at board, or on paper) showing the form of the "Big Dipper," and its position relative to the North Star.

(*f*) If any change occurs in the brightness of the same star night after night, aside from effects of atmospheric conditions.

7. From books and other sources secure information on the following topics: —

(*a*) The names of the eight *planets* of our *solar system* in order of their distances from the sun.

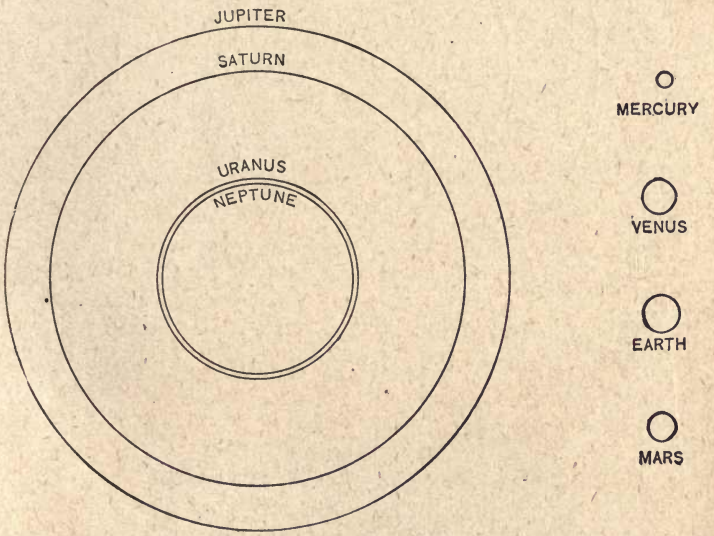


FIG. 87. — Relative sizes of the planets.

(*b*) The distinctions between star and planet as to their sources of light, and their physical states.

(*c*) A diagram to show the relative sizes of the planets.

(*d*) A diagram to show the relative distances of the planets from the sun.

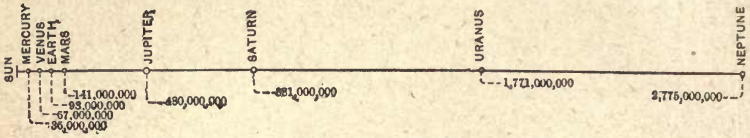


FIG. 88. — Distances of the planets from the sun.

(*e*) The views concerning the *universe* held by the ancients. The knowledge Columbus had of the earth's size and form.

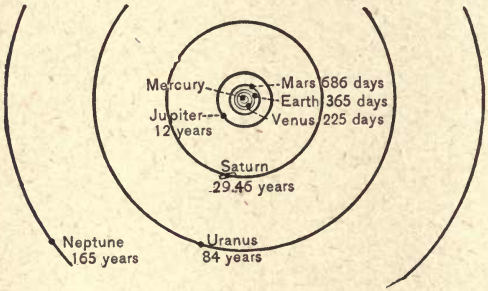


FIG. 89. — Periods of revolution of the planets (length of their years).

(*f*) The distance from sun to earth. The time required for light to traverse that distance. The time required for

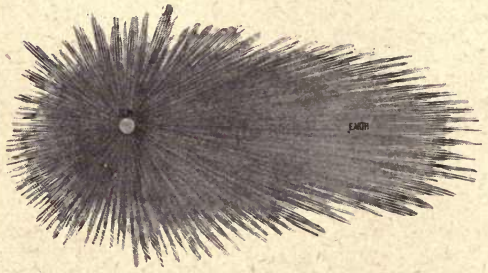


FIG. 90. — It is calculated that the earth receives about one two-billionth of the heat and light given off by the sun.

light from the nearer stars to reach the earth, and the time from the more distant stars.

(*g*) The two motions of the moon as the earth moves on around the sun in its path of revolution. The meaning of the term satellite as applied to the moon.

(*h*) The relative intensity (degree) of heat and light from the sun upon Mercury, Earth, Neptune.

(*i*) The length of the years for the different planets, *i.e.*, their periods of revolution around the sun.

APPENDIX

LIST OF APPARATUS AND SUPPLIES, AND THEIR COST

Everything required in these Lessons as apparatus and supplies will be found in the equipment commonly provided for teaching the high school sciences. Good substitutes for many articles named may easily be arranged. It will always be best, however, to have separate supplies for the work in General Science, and to have them kept for this use only.

As a reference list when purchases are to be made it will be found convenient to note what the Lessons call for as given below. The prices named are approximate only, and the articles named may be had of any of the supply and apparatus houses. Articles commonly at hand anywhere, or readily obtainable at home, are not listed. Collections of garden seeds and of grains may be kept in small bottles properly labeled, and seeds of various trees may be kept in cigar boxes. Such supplies are readily provided for class use during the year.

Type forms of leaves and roots and flowers, suitably mounted, together with exhibits of various rock and ore specimens on cardboard (securely sewed in place), are desirable additions to the stock of supplies. Some of the large industries have "School Exhibits," which may be secured at nominal charge; these show the various stages of manufacture of raw materials into marketable products.

[It is to be remembered that the books and bulletins listed elsewhere are considered an essential part of the working material for these Lessons.]

acids: —

hydrochloric, 1 lb., with bottle	$.25
nitric, 1 lb., with bottle	.30
sulphuric, 4 lbs., with bottle	.55

alcohol, denatured, 1 quart	$.45
ammonia, 1 lb., with bottle	.30
balances, specific gravity	4.50
balances, spring, 64 oz., 2000 grams, each	.40
barometer	15.00
barometer tube	.20
blast lamp [1]	3.25
bleaching powder, can	.15
blowpipe, 8-inch	.08
borax, 1 lb.	.15
bottles, wide-mouth, 8 oz.	.05
bottles, screw cap, for seeds and grains, 2 oz.	.06
burette clamp, iron	.30
candles, small wax, per box	.10
cells, dry, each	.25
cells, simple voltaic	.50
chimneys, student-lamp	.06
compass, magnetic, 2-inch	.30
connectors, double, for battery wires	.10
diffusion shells, 100 × 16 mm.	.25
electric bell, 2½-inch	.40
ether, 1 oz.	.10
evaporating dishes, 3-inch	.15
Fehling's solutions, 1 oz. each	.15
file, triangular, 6-inch	.10
filter paper, pkg. of 100, 10 cm.	.10
funnel, 3½-inch	.14
glass cutter, 5 wheel	.30
glass jar (½ gallon battery jar)	.20
glass plates, blue and red, each 2″ × 3″	.05
glass tubing, ¼-inch, 5 lbs.	2.00
graduate, 100 c.c.	.50
iodine solution, 2 oz.	.20

[1] Some means must be provided for heat in case the room for General Science does not have gas burners. A plumber's torch is very satisfactory. Pipettes and elbow tubes may then be made as needed from glass tubing.

jug, one gallon	$.35
labels, box	.08
lever holders	.30
limewater (to be made)	
litmus paper, sheets, red and blue, each	.04
magnets, bar, in box, per pair, 6-inch	.45
magnet, electro-, 3-inch	1.25
magnifiers, watchmaker's	.40
mercury, 1 lb., in bottle	1.50
metric (foot) rules, 1 dozen	.35
meter stick, brass tips	.35
mirror, plane, 6-inch strips	.10
mortar, 3-inch	.36
paraffine, 1 lb.	.16
potassium chlorate, 1 lb.	.35
prism, equilateral, 3-inch	.25
protractors, manilla card	.06
pulleys, triple-tandem, pair	2.25
pumps, glass models, lift and force	2.65
ringstand, 2 rings, 18-inch	.40
rubber stoppers, —	
one-hole for test tubes	.03
two-hole for wide-mouth bottles	.12
rubber, thin sheet, per sq. ft.	.30
rubber tubing, $\frac{3}{16}$-inch, 12 ft.	.75
shears, common, 5-inch	.50
sodium bicarbonate, 1 lb.	.10
sodium carbonate, 1 lb.	.10
sphere (toy globe)	.10
spoons, iron, tea, per doz.	.25
sugar, grape (glucose), 1 lb.	.10
telegraph key	1.15
telegraph sounder	2.00
test tubes, 6 $\times$ $\frac{5}{8}$ inch, per dozen	.25
test tube brush	.05
test tube rack, wood	.25

thermometer, chemical, C. & F.	$.80
thistle tube	.08
vaseline, bottle	.05
weights, metric, set, 1 to 500 grams	1.75
weights, metric, fractional, each	.05
wire, copper, No. 22, insulated, ¼ lb.	.30
wire gauze, asbestos center, 5″ × 5″	.09
wire, iron, No. 24, annealed, 4 oz.	.16
wire pliers, side-cut, 6-inch	.70

A LIBRARY LIST OF REFERENCE BOOKS

Books should be considered tools for the use of pupils. To learn to use them aright is fundamental in school work, and one of its chief aims. Knowing where to find needed information, coupled with a desire for knowledge, constitutes no small part of an education. In the books listed below, there is provided a fund of information on the topics of these Lessons that is worthy the best efforts of every pupil.

One book generally suffices as a text in any subject in school work. But in General Science no one book is likely to provide all the material that very properly comes under discussion. In some cases it may be desirable to have several copies of the less expensive books where these are of superior worth and usefulness. For class instruction this is often wiser than to make the same outlay for single copies of all the books named. To have the use of only one book in General Science, however valuable the results attained may be, is to suffer somewhat the same limitations as does the carpenter who for tools has but a jackknife. The skilled mechanic selects from his large assortment that particular tool best suited to his purpose.

Teaching conditions may render impossible any extended use of reference books, but no apology is needed for having provided a generous reference list. The use of these books and others of like character will enrich the course. While library equipment and the preferences of instructors may make desirable many substitutions in any list named, it is urged that the greatest care be exercised in the selection of references.

Where a double period for daily laboratory and class work is arranged, no lesson preparation outside those hours will be necessary. In addition to recitation and experimental work there is in this arrangement an opportunity under favorable conditions to teach pupils how to study, and to direct their desire for knowledge along lines that offer the largest educational values.

Bailey (Mac.), Sanitary and Applied Chemistry	$1.40
Bengtson & Griffith (Mac.), The Wheat Industry	.65
Bigelow (Mac.), Applied Biology	1.40
Blakeslee & Jarvis (Mac.), Trees in Winter	2.00
Brownell (T. P.), Lessons in Physics	.75
Brownell (T. P.), Lessons in Chemistry	.50
Caldwell & Eikenberry (G.), General Science	.80
Clark (Am.), Introduction to Science	1.20
Coleman (Mac.), Hygienic Physiology	.60
Coleman (Mac.), The People's Health	.70
Conn (G.), Bacteria, Yeasts, and Molds	1.00
Coulter, J. G. (Am.), Plant Life, and Plant Studies	1.20
Coulter & Patterson (Ap.), Practical Nature Study	1.35
Crawford (Hi.), Nature Study Lessons	.75
Doty (Ap.), Prompt Aid to the Injured	1.50
Freeman & Chandler (G.), World's Commercial Products	2.75
Goff (Co.), Principles of Plant Culture	1.00
Harper (Mac.), Animal Husbandry for Schools	1.40

Harrington (Ap.), About the Weather	$.60
Hessler (San.), First Year of Science	1.25
Hooker (Am.), Child's Book of Nature, Part III	.50
Jewett (G.), The Next Generation	.75
Kinne & Cooley (Mac.), Foods and Household Management	1.10
Lipman (Mac.), Bacteria in Relation to Country Life	1.50
Parloa (Cen.), Home Economics	1.00
Price (Wi.), Handbook on Sanitation	1.50
Price (Sm.), The Land We Live In	1.50
Rowell (Mac.), Introduction to General Science	.75
Snell (Mac.), Elementary Household Chemistry	1.25
Snyder (Mac.), Chemistry of Plant and Animal Life	1.50
Tarr (Mac.), New Physical Geography	1.00
Tarr & McMurry (Mac.), New Geography, Second Book	1.10
Warren (Mac.), Elements of Agriculture	1.10
Williams & Fisher (Mac.), Elements of Theory and Practice of Cookery	1.00
Wilson & Warburton (Web.), Field Crops	1.50

The free use of high school science texts serves many excellent ends. Aside from the information for immediate use furnished by them in a concise, attractive, and reliable form, pupils with active minds will scarcely fail to find in some one of these fields of science that which will arouse a desire to go beyond a course in general science. Texts and manuals in Agriculture, Botany, Chemistry, Geology, Home Economics, Meteorology, Physics, Physical Geography, Zoölogy, etc., should have extended use as reference books in connection with General Science.

The publishers of the books listed above are as follows: —
(Mac.) The Macmillan Company: New York.
(Ap.) Appleton & Co.: New York.
(G.) Ginn & Co.: Boston.
(Am.) American Book Co.: New York.
(Wi.) Wiley & Sons: New York.

(Hin.) Hinds, Noble & Eldredge: New York.
(Cen.) Century Company: New York.
(T. P.) The Torch Press: Cedar Rapids, Ia.
(Co.) Co-operative Company: Madison, Wis.
(Sm.) Small, Maynard & Co.: New York.
(San.) Benj. Sanborn & Co.: New York.
(Web.) Webb Publishing Co.: St. Paul, Minn.

LIST OF BULLETINS

U. S. DEPARTMENT OF AGRICULTURE, WASHINGTON, D.C.

Farmers' Bulletins [1]

No.
54 Some Common Birds.
55 The Dairy Herd.
106 Breeds of Dairy Cattle.
128 Eggs, and Their Uses as Food.
134 Tree Planting on Rural School Grounds.
157 The Propagation of Plants.
173 Primer of Forestry, Part I.
181 Pruning.
183 Meat on the Farm.
218 The School Garden.
245 Renovation of Worn-out Soils.
249 Cereal Breakfast Foods.
255 The Home Vegetable Garden.
266 Management of Soils to Conserve Moisture.

[1] Order through the Congressman from your district. It will be well to have several copies each of some of these Bulletins. All give valuable information in form available for teaching. One of the purposes of their publication is school use. No charge is made for them.

It is suggested that provision be made for the proper care of all Bulletins from their first use. One good way is to bind them more or less durably into sets of related titles, with labels giving the bulletin numbers and names in each set, and then as needed these sets can be put out for use protected by covers such as are used with magazines in public reading rooms.

No.
270 Modern Conveniences for the Farm Home.
287 Poultry Management.
293 Use of Fruit as Food.
298 Food Value of Corn and Corn Products.
345 Some Common Disinfectants.
355 A Successful Poultry and Dairy Farm.
358 Primer of Forestry, Part II.
363 The Use of Milk as a Food.
369 How to Destroy Rats.
375 Care of Food in the Home.
377 Harmfulness of Headache Powders.
389 Bread and Bread-Making.
393 Habit Forming Agents.
413 The Care of Milk, and its Use in the Home.
447 Bees.
450 Facts about Malaria.
463 The Sanitary Privy.
473 Tuberculosis.
475 Ice Houses.
478 How to Prevent Typhoid Fever.
491 Profitable Management of Small Apple Orchards.
492 The More Important Insect and Fungous Enemies of the Apple.
493 The English Sparrow as a Pest.
607 The Farm Kitchen as a Workshop.
617 School Lessons on Corn.
630 Some Common Birds Useful to the Farmer.
679 House Flies.

Bulletin 100, Bureau of Chemistry $0.10
Circular 125, Bureau of Animal Industry 0.10
Circular 19, Division of Publications Free
(A list of the Publications of the Department of Agriculture Classified for Teachers.)
Circular 29 on Stock Judging, Purdue University: La Fayette, Ind. (Agricultural Extension) $0.10
Board of Health of your State, — Rules and Regulations . . Free

REFERENCES FOR CLASS ASSIGNMENTS[1]

I. The Human Body

1. The hand — Bigelow, pp. 519–522; Coleman (Physiology), pp. 16–23; Crawford, pp. 14–17.
2. The mouth — Bigelow, pp. 465–468; Coleman (Health), pp. 109–113; Coleman (Physiology), pp. 102–103, 152–157, 243.
3. The eye — Bigelow, pp. 515–518; Crawford, pp. 5–7; Coleman (Physiology), pp. 248–255.

II. Heat in Relation to the Human Body

1. Combustion — Brownell (Chemistry), pp. 13–14, 34–38. (Any good text in Chemistry.)
2. Ventilation — Price, pp. 15–41.
3. Respiration — Bigelow, pp. 110–114, 502–506, 526–528; Coleman (Physiology), pp. 104–121; Coleman (Health), pp. 20–41; Doty, pp. 170–177.
4. The human body as an engine — Bigelow, pp. 492–499; Coleman (Physiology), pp. 138–141.
5. Regulation of body temperature — Bigelow, pp. 522–524, 533–555.

III. Health and Well-Being

1. Keeping well — Coleman (Physiology), pp. 201–214; Coleman (Health), pp. 1–8.
2. Infection — Bigelow, pp. 276–297, 554–560; Coleman (Health), pp. 11–19, 114–130; Coleman (Physiology), pp. 122–132, 267; Conn, pp. 100–138, 203–266; Doty, pp. 91–111; Farmers' Bulletin, No. 345; Lipman, pp. 1–25; Price, pp. 269–285; Regulations of the State Board of Health.
3. Sanitation — Bailey, pp. 106–116; Coleman (Health), pp. 190–214; Lipman, pp. 56–98; Bulletin 100, Bureau of Chemistry, U. S. Dept. of Agriculture, pp. 8–11; Farmers' Bulletins, Nos. 270, 375, 478.

[1] Make free use of any good texts in General Science for all these lessons. Use the Index of any text to find the desired information quickly. If one text does not have what is wanted, consult another.

4. The water supply and health — Coleman (Health), pp. 42–55; Price, pp. 46–52.
5. General health problems — Bailey, pp. 79–91, 297–307; Bigelow, pp. 312–314, 393–397; Coleman (Health), pp. 74–92, 132–152, 217–260; Conn, pp. 139–181; Doty, pp. 203–219; Lipman, pp. 103–134, 431–446; Price, pp. 54–71; Circular 125, Bureau of Animal Industry, U. S. Dept. of Agriculture; Farmers' Bulletins, Nos. 345, 369, 450, 459, 473. (Various Bulletins from the State Board of Health.)
6. Life, growth, rest, and recreation — Bigelow, pp. 13–21, 44–57, 122–126; Coleman (Health), pp. 8–11, 153–163; Coleman (Physiology), pp. 1–13.
7. Stimulants and narcotics — Bailey, pp. 257–287; Bigelow, pp. 539–554; Coleman (Physiology), pp. 27, 100, 151, 180, 214–237; Coleman (Health), pp. 164–176; Farmers' Bulletins, Nos. 377, 393; Jewett, pp. 118–125, 136–152.
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